How to Become a Competent Motorman

HOW TO BECOME

A

COMPETENT MOTORMAN;

BEING

A Practical Treatise on the Proper Method of Operating a Street Railway Motor-Car; also giving details how to Overcome Certain Defects

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INTRODUCTION.

The object of this book is to instruct motormen in the proper handling of the different electric equipments now being used by electric railway companies throughout the entire world.

Enormous strides have been made in electric railway construction in the last five years, and it is obvious that in a few years steam rail-roading will be a thing of the past.

Experienced engineers have given out detailed calculations which plainly shows, that the adoption of electricity as the motive power of all trains on one of the leading railroad systems of this country, would mean a saving to that system in operating expenses alone of not less than six million dollars annually. If this be correct, and indeed it seems plausible enough, then electricity will supersede steam over this entire continent within a few years. It is estimated that over one hundred million dollars are invested

annually in building electric railways, so that competent motormen will always be in demand. To become competent, a motorman should always be on the alert and intelligently associate himself with the workings of his car, and whenever anything happens to his car he should ascertain what the trouble is and whether it could have been avoided or not.

Oftentimes, a car has to be towed to the car house, whereas if the motorman was acquainted with the different connections he could have made temporary repairs so as to finish his day's work or until he got to the car house. If he lacks the knowledge to accomplish this, he must let it alone. If, however, he can make temporary repairs in a hurry so as not to inconvenience the patrons of the line, he certainly paves the way for his own advancement.

The position of motorman is one of much importance, as every motorman is responsible for the safety of his car and passengers, also for the lives of the people crossing the street immediately in front of him. He must be quick to think and act, and this comes not

only from experience in handling cars, but also from an intelligent understanding of the power under his control.

In some cities motormen now have to pass an examination before they are allowed to operate a car, and when this shall have become general, as it undoubtedly will in time, a man will not be allowed to run a car through the city unless he has a license and is thoroughly conversant with the workings of the car.

This book has been gotten up in as plain and as simple a manner as possible, so that any one can readily understand every word contained between its covers, and understanding it would certainly make him competent to pass any examination that would be required of him to become a motorman.

It is made in a convenient form, so as to be carried in the pocket, and can be referred to at any time.

RHEOSTATIC METHOD.

The first system that will be considered is the Rheostat System, which is now practically out of existence. The idea of a rheostat is a device for controlling the electric current and for diminishing or increasing its flow, and therefore the work which it does. The office of a rheostat as used to start up an electric motor is similar to that of a steam valve on a steam engine; that is, it is simply used to give a gradual admittance of the current to the motor, and is usually cut entirely out of circuit as soon as the motors reach their maximum speed. The necessity of the rheostat can be explained by carrying the analogy of the steam valve a little farther. The construction of the motor is such that when it is at rest the full admittance of the current would destroy it, just as the full admittance of the steam to the steam engine cylinder would be almost sure to strain or break some of its parts.

The plan upon which all rheostats are constructed is such an arrangement of electrical

conductors of greater or lesser resistance that they may be readily thrown into circuit.

Different makers differ in the mounting and the way of connecting the circuit, yet the general principle of their construction is the same.

In the T. H. rheostatic method of control, the motors are connected permanently in parallel, which means that the current is divided, one branch passing through each motor. If a pressure of 500 volts were directly applied to any motor, it would have a tendency to strip the gears and pinions, and possibly to short circuit field coils, and armature, and also to carbonize the brush holder yokes.

You will readily understand, therefore, the necessity to temper or reduce this pressure and apply to each motor at the start less than half the total voltage, gradually increasing the pressure or voltage, thereby increasing the speed of the car until it reaches its maximum speed.

There are two types of rheostats, known as the D-51 and the D-81, manufactured by the T. H. Electric Company. The D-51 rheostat is semi-circular in shape while the D-81 is of a circular shape.

The type D-51 is composed of an iron frame with a recess for inserting the resistance plates, and also in connection with these are placed the sliding contact plates, these plates are in a series connection with a certain amount of resistance allowed, terminating and connecting with a contact plate on which is connected a wire leading to the field circuit of motors. Also exterior, in the rheostat body or frame, is another contact plate on which is connected a wire leading to the field circuit. The first of these wires is called the end wire, and the second wire is called the loop wire.

T. H. RHEOSTAT TYPE 51 D.

The end wire connects with the entire field circuit while the loop wire cuts out a portion of that circuit. When the end wire is in circuit the motor is at its full field strength, but when the loop wire is placed in circuit the field strength is reduced about one-half, which allows an increase of speed held with the armatures.

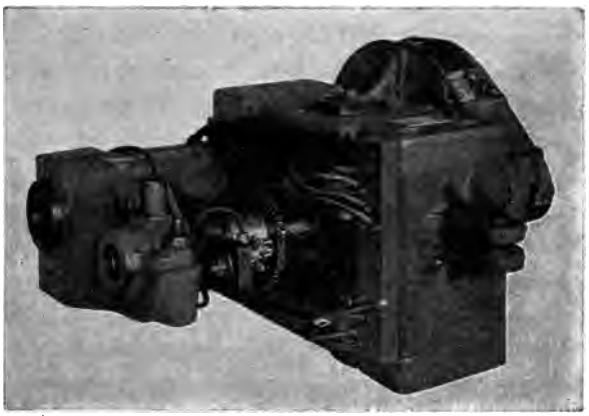
The type D-81 rheostat is the one used practically by the surface railway systems of the present day, where used at all, but the more modern controlling devices are fast taking their place on account of economy in consumption of power, as well as cost of maintenance.

As previously stated, the D-81 is circular in shape, at the centre of which is placed a steel spindle which is insulated from the frame by a vulcabestos bushing. Attached to the spindle is an arm which extends out far enough to cover the conductors or sliding contact plates of the rheostat, at the end of which is attached the sliding contact shoe, which is, when operated, placed in metallic connection with the sliding contact plates of the rheostat. The rheostat arm is propelled or moved

around by what is known as the rheostat drum or pulley. This drum is composed of wood usually, on the bottom side of which is attached a U-shape casting, which is extended so as to secure the rheostat arm for operation.

The rheostat is controlled by what is known as the rheostat cables which are attached to the rheostat drum and secured by a staple. This cable has one complete turn around the drum, the ends of which are attached to sprocket chains. The other part of the cable circuit is called the floating cable, the ends of which are attached to the opposite ends of the sprocket chains. The cable is operated by what is called the sprocket wheel, the cogs of which mesh with the sprocket chain. The sprocket wheel is operated by a spindle which extends from the top to the bottom of the controller's stand, the spindle being operated by an ordinary crank handle.

The rheostat just described was the first type of resistance used in connection with street railway motors in the earlier day of electric railway motors.



T. H. S. R. G. MOTOR

The rheostats of the present day are of a different type and build and they are composed of a long strip of annealed band iron which is placed up in layers, each layer being insulated from each other by asbestos or mica which when formed is known as a panel of resistance. The number of panels usually placed in a rheostat frame are six in number, each one having a certain amount of resistance, and are placed in series connection with terminal binding posts, attached for connecting rheostatic wires from the

controller which cut in certain sections, represented by its individual wire. One type is known as the block type of rheostat while other types are of a cylindrical shape, but the office of each is identical.

CONTROLLERS.

The controller is probably the most important and to a certainty the most complicated part of an electric car equipment.

Its position is always at the outer end of the car platform and through its mechanism the current is led to the motors and resistance, thereby producing the several combinations to determine the several speeds which the car shall take. In stating that the position of the controller is always at the platform end, I mean at the present time, as I remember some years ago when the Vanderpoele system was in use that the motor and starting box was inside of the car at about the centre. The car was propelled by means of a sprocket chain running from a sprocket wheel on the armature shaft to a sprocket wheel on the

car axle. There has been three distinct types or methods of control which have been put into use in connection with the propulsion of cars. The first that was used to any extent was that of the Sprague system. In this system the field coils were divided into several sections and these sections, together with the armatures, formed the several steps or combinations which were to vary the speed. The second form is that in which the field and armature circuits remain unchanged, while a heavy resistance is placed in circuit with them. The resistance method of control is the simplest of any which has at any time been adopted, and by it an almost perfect control is had over the speed of the car. By this method the car can be started and its speed increased up to the limit very gradually, and without any perceptible jar whatever, and at all times, except when at full speed, the entire current used in propelling the car passes through more or less of the resistance, which causes a considerable loss of current, and it is owing chiefly to the loss of power that it has been succeeded by the series parallel method of control.

Of the many types of controllers which are manufactured by the General Electric Company, the types known as the Type K, K-1, K-2, K-10, and K-11 are the types generally used by street railway companies, and, most especially at the present date, the two latter types, K-10 and K-11, are the ones generally adopted. The types K and K-1 are identical except in the build of the connection board, the difference being that in the type K each lead wire of cable is secured to binding post of connection board by means of a crow-foot terminal, and secured to the binding post by a nut; while in that of type K-1 the connection board is equipped with socket binding post, and each lead of cable is secured in socket by means of a set screw. The type K or K-1 controller is so constructed as to cut in a resistance, exterior to the motor circuit, in the application of the power, and is divided into seven separate sections and are known as operating positions, of which the first, second and fifth are called rheostatic positions, meaning that the rheostat is in connection with motor circuit; while the third and sixth positions are

known as safe running positions, meaning that there is no resistance connection with motor circuit, the current being direct to motors; also the fourth and seventh positions are safe running positions, and are known as shunt positions, meaning that a portion of the current is shunted from each motor's field circuit, which allows an increase of speed excessive to that of the third and sixth positions. These two positions should never be used in ascending a heavy grade, or for long, continuous heavy hauling with motors. The types K, K-1 and K-2 are practically identical, except that the type K-2 is arranged for one more section of resistance than the type K or K-1, which requires one more connection and contact in addition to that found in the type K and K-1, so that a description of the K-2 will also apply to the K or K-1 controller. The K-2 controller has two cylinders, one the controlling cylinder and the other the reverse cylinder. The controlling cylinder extends from the top downwards and consists of segments of circles, which are known as contact plates of which there are twelve divisions. At the left

of cylinder are the twelve contact wipers or fingers of the controlling cylinder, while to the right is the reversing cylinder and its eight wipers or fingers. At the bottom of the controller and on the left side are the two cut-out switches, number one to the left and number 2 to the right, and the raising of either one cuts out either motor as may be desired,—that is, to cut out motor number 1 raise the large switch at the left, and to cut out motor number 2 raise the smaller one which is the one on the right side. In raising either switch be sure and raise it up as far as it will go. The raising of either switch automatically sets a stop, which prevents the cylinder from being turned beyond the proper point which is the fifth position. At the bottom and to the right is the main connection board with all the cable terminals coming up through the floor of the platform and up into the bottom of the controller. Just above the connection board is located an electro-magnet, designed for blowing out the arcs formed at the contact wipers or fingers. This magnet is connected in on the main circuit, and all the current which is consumed

by the motors at any time first passes through this magnet, so that the heavier the current and the consequent tendency to arc, the stronger is the magnet and its corresponding power for blowing out the arc. One pole of the magnet is hinged and swings out from the controller and leaves the contact fingers exposed. When closed this pole is directly over the contact fingers, the other pole is the iron casting at the back of the controller case. The reversing cylinder is simple in its construction and can be easily got at when the cover of the controller is thrown back. The controller covers should always be kept tight, to exclude dust and water, and it is a motorman's duty to report the defect to the man in charge in case he finds one open, so that the defect may be remedied. When dust gets in these controllers it diminishes the life of the contact fingers, as it gets between the fingers and contact plates, which has a tendency to cut the same; and if water gets in it is still more destructive, as it is liable to ground the controller, which would result in it having to be taken out of service. Cars with grounded

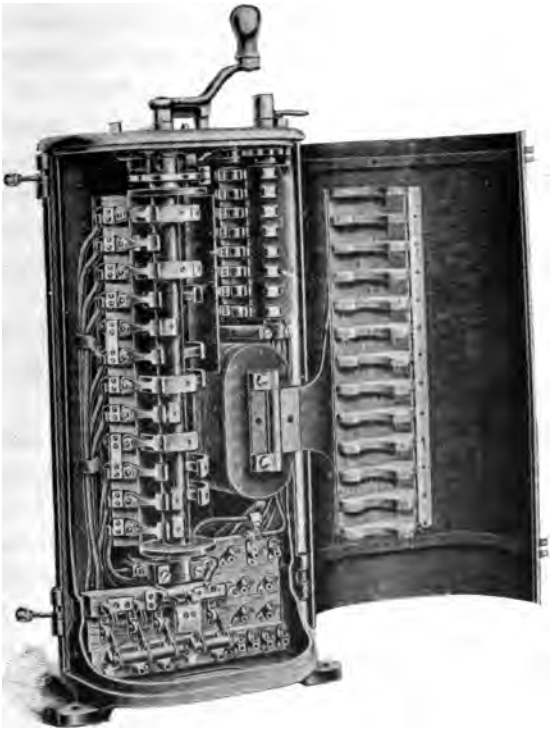
controllers are usually pushed or towed into car house, because if you try to operate your car by the opposite controller the current will back up in the grounded controller and possibly produce a heavy arc. To prevent this you should open the controller cover, and you will see on the connection board where it is blackened up and charred. You should disconnect all the wires on the board where the ground is, and be sure as you disconnect them to clear them away from the controller and from each other, or they will produce a short circuit or heavy arc again. If on starting up you should still find that the current backed up it would only take a short while to disconnect them all; then you would be safe to run from the other controller, but do not forget to separate the wires. The reversing handle cannot be taken off or put on except in the mid or neutral position, which is a good feature, as all of the connections are then broken and the power cylinder is locked and cannot be moved until the reverse is thrown. The setting of the reversing handle indicates the direction in which the car will be moved, and the power cannot be

applied until the handle is fully thrown either backward or forward.

Also another splendid feature is, that the reversing handle cannot be moved unless the power is fully thrown off and this makes it impossible for a motorman to reverse his car with a full head of power on. A dial on the cap plate indicates at what point the connections of the cylinder are set. An arrangement of spring roller and cam wheel clearly marks the notches to the touch, so that a motorman can feel the successive steps, while keeping his eyes constantly on the track in front of him. If you have a car and one of the controllers does not give the notches as it should, you should report the defect to the person in charge. You can easily tell when a controller has this defect, because you will not hear the click that it gives when in order. The cause of this is, that the cam roller spring is either broken or has become detached, or the rivet going through the cam roller is worn through, or perhaps the cam or star wheel is loose on the spindle. These controllers are automatic in every detail and should check

any tendency to carelessness or forgetfulness on the part of a motorman. These controllers are known as series parallel controllers, and this method of control differs from the rheostatic method in this way, that with the rheostatic method, the motors are connected permanently in parallel, while with the series parallel method, the motors are first temporarily connected in series, the current first passing through one motor and then through the other without division. By this means, together with a slight resistance, the proper starting pressure is applied, and the motors being in series, the same current that starts one flows through and is used over again in the other. After the car is started, the voltage applied to each motor is gradually increased by throwing both motors in parallel. The safe running positions on a seven-notch controller are three and six, and on a nine notch four and eight. Where the shunt resistance is used the loop would be the fourth and seventh position on a seven-point controller, and the fifth and ninth position on a nine-point controller. When running on the

last-mentioned points, all the current passes through the armatures of the motors as usual, but only part passes through the field coils; a considerable amount flows through this shunt resistance, the effect of which is to weaken the field strength of motor, but leaves the armature practically of the same strength as when running on the notch immediately preceding. The effect of this is, of course, an added effort of the motors, with a corresponding increase in the speed. These positions should never be used in ascending a heavy grade, because it is a severe strain on the motors and is liable to cause trouble which will delay your car a great deal longer than if you had followed the instructions and run on the safe points. The power should never be applied more than one notch at a time and then allow the motor time to pick up before moving to the next. If your car is running too fast and you want to reduce the speed, always throw your power off all the way and commence to build up again.



GENERAL ELECTRICAL SERIES—PARALLEL CONTROLLER, FORM K-2, FOURTH POSITION.

MOTOR CIRCUIT.

The following is the course the current takes with the K-2 controller on the different positions:

FIRST POSITION.—The current passes from the controller through all the resistance and then through the armature circuit of the number 1 motor and through the field circuit of number 1 motor through the armature circuit of number 2 motor, through the field circuit of number 2 motor and from there to the ground. The motors are now running in series.

SECOND POSITION.—The same as on the first position, excepting that a part of the resistance is cut out of the circuit.

THIRD POSITION.—The same as on the second position excepting that more of the resistance is cut out of the circuit.

FOURTH POSITION.—The same as on the third position excepting that all of the resistance is out of the circuit the current being direct to the motors.

FIFTH POSITION.—All resistance is still cut out, but the fields are weakened by the use of a shunt, and the motors still remain in series.

SIXTH POSITION.—All the current passes through part of the resistance and then through armature and field circuit of number 1 motor and armature and field circuit of number 2 motor at the same time and from there to the ground. The motors are now running in parallel.

SEVENTH POSITION.—The same as on the sixth position excepting that part of the resistance is cut out of the circuit.

EIGHTH POSITION.—The same as on the seventh excepting that all the resistance is cut out of the circuit. The power should never be put beyond this position in ascending a heavy grade.

NINTH POSITION.—All the resistance is out of the circuit and the fields are weakened by a shunt coil. This position is only intended to be used on a level track and where there is no danger from fast running. The motors are still in parallel.

The course of the current in a K and K-1 is the same as in a K-2 excepting that there is one more resistance point in the K-2 which makes the difference of two points, one in the series points, and one in the parallel points,

while the K-10 and K-11 has one more point of resistance and no shunt.

By carefully studying the course the current takes on each successive step you will readily see that when you get to the safe points on the controller that the resistance is entirely out of the circuit, and there is no reason for it heating if run on the safe positions, unless you carelessly disregard the rules as laid down and car is run on the resistance points. You will notice on the dial-plate that some of the notches are longer than the rest. The short notches are the resistance notches and the long ones are the safe running notches.

Of course where a new resistance has been put up it will possibly heat up a little in moving the power from one notch to another if the car is heavily loaded and the power is applied slowly, but it will only heat just enough so that you can smell any paint which may have been put on, but there is no danger of any damage. In connection with resistance it might be well to remind you that you should not run through water with the power on, especially on the resistance points, because it might short-circuit or burn

out the resistance; besides, it might cause the controller to blow or arc from trolley wiper to the controller frame. Where there is a long stretch of track covered with water, of course you would have to use power, but run through it very slowly, so that the wheels will not throw the water all over the motors. All wires and cables are supposed to be placed out of the line of the wheel-throw as much as possible, but still, if the car is run too fast, a great deal of water will splash over the motors and perhaps ground a brush holder, field coil or armature if it gets into the motors.

As an illustration, you pour water on a grindstone, and the faster you turn the stone the farther it will throw the water, and the same way with a car wheel.

WESTINGHOUSE CONTROLLER.

The Westinghouse Company has made many different forms of controllers while adhering to the general form of motor. The earlier forms of Westinghouse controllers are known by the alphabetical order in which

they run, from the letter A on and as far as the letter G inclusive. Controllers B. C. D. and E. were put out with their earlier types of motors and which were arranged for parallel running. The type G was first adapted for series parallel running but was afterwards superseded by type 14. This later was followed by the type 28-A controller. The most commonly used at the present with series parallel motors is the number 14 or number 28-A controllers. A description of type number 14 is as follows:

Upon opening the controller you will notice that the eleven contact wipers or fingers are shown at the left of the controller, also the twelve main cable terminals at the bottom, and the two cut out plugs near the centre and at the right hand side. The reversing switch differs from the General Electric in form. It is in the form of a flat disc of slate or porcelain and is located immediately underneath the heavy brass top of the controller. With this controller there are six speed points. The first two have resistance in series with both motors in series. At the third point both motors are in series with

all the resistance cut out; at the fourth and fifth positions the motors are in parallel each having resistance in their circuit, and at the sixth position the motors are in parallel with all resistance cut out. The controller known as the 28-A is quite similar to the type 14 differing from it only in its mechanical construction. The method of reversing is the same excepting that the handle is placed at the top of the controller instead of at the side as in the type number 14. The cylinder is not arranged to swing open as in type 14 but may be readily taken out to make repairs. The main cable terminals are distributed at the sides and bottom of the controller.

The cut-outs also are slightly different in form. With the type 14 controller, when motor number 1 is cut out, motor number 2 will not start until the controller handle is thrown over to the fourth position, and in order to operate your car, notches number 4, 5, and 6 are used. When motor number 2 is cut out your car will take power on number 1, 2, and 3 positions. With the type 28-A controller, no matter which motor is cut out

of circuit, the remaining motor is operated on notches 1, 2, 3, and 4, the controller being locked from passing beyond this point.

CURTIS CONTROLLER.

The Curtis Controller is a series parallel controller, and in general principles is the same as all others of the same method. On the Form A controllers the running notches are 3 and 7, and on the Form B the third and fifth positions. The first three points are series points, and the last points are parallel. This controller has no blow magnet coil, as the General Electric controllers have, but has arc deflectors between each wiper or contact finger. Neither has it motor cut-outs for cutting out a defective motor, and in case of a defective motor, the motor leads have to be disconnected at the motor, the same as the W. P.-50 T. H. motor when used in connection with the rheostatic method of control.

This controller has no connection board at the bottom of the controller, but is connected up on either side, the armature and field

wires going to the reverse side and the resistance wires, trolley and ground wires connect up on the left side to the wiper board. The setting of the reverse handle indicates the direction the car will move, and great care should be taken that the reverse handle is not pulled back or moved in any way while the power is on, as it is very injurious to the controller, and it would be plain to see how the damage was done by opening the controller cover; besides, if you wanted to make a quick stop, this way is not reliable, as the fuse would surely blow if you pulled over the reverse lever with the power on. When it becomes necessary to reverse the car, to stop in case of an emergency, first throw off the power, then pull the reverse lever and apply the power, and then your fuse is not as liable to blow. An arrangement of cam roller and wheel plainly marks to the touch the successive steps, so that the motorman does not have to watch the dial plate, but can be on the lookout to see that the track is clear ahead. As before stated, to cut out a motor, the connections have to be disconnected at the motor, and you will

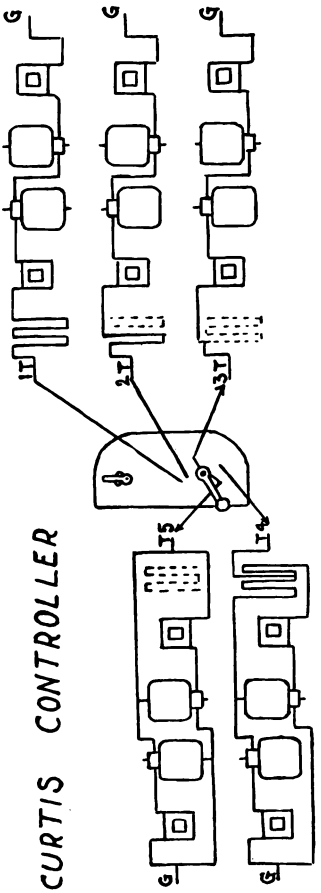


Diagram showing the course of current through the resistance on each position of controller, the unbroken line showing the amount of resistance in, and the broken line showing the amount cut out.

find that the car will not start until the handle is moved to the fourth position. This can be remedied, however, by closing the field and armature circuits. After disconnecting a defective motor, connect together the two brush wires and then connect together the two field wires. The wires that you are to connect together are the wires coming out of the body of the car, and not the wires coming out of the motor. This will give you power on the first three notches, and the controller should not be operated beyond this position. You should exercise great care in the handling of these controllers, and be sure to work them on the notches and not half way between.

WALKER CONTROLLER.

In this controller the arc is broken by a cylinder placed in the controller for that purpose. The circuit is broken at twenty-eight points, and is supposed to render the most severe arc entirely harmless. Another feature consists in entirely separating the operating of breaking the circuit from the

controlling cylinder. The controller consists of two cylinders. The controlling cylinder proper, is used to make the different combinations required to obtain the proper regulation of the speed of the car for acceleration. The second cylinder is used for the breaking of the circuit whenever such is required. The arc-breaking cylinder which is to the left of the controlling cylinder has its circuit so arranged that the main current passes first through it before going to the controlling cylinder. The mechanism of the arc-breaking cylinder is so arranged that with a slight movement of the controller handle backwards, the circuit is completely opened leaving the controlling cylinder entirely dead. The controller cannot be closed again until the controlling handle has been brought back to the off position. After the circuit has been opened by the slight backward movement of the controlling handle, the controlling cylinder can be moved backward and forward into any position without producing any effect, and it is absolutely necessary to go back to the off position before the circuit can be closed. This feature makes it impossible to drop back

from one notch to another in such a way as to put in or take out resistance in the circuit. A slight movement of the handle backwards cuts off the current from the car, thus leaving the motorman free to attend to his brake. There is also an interlocking device whereby the pawl that indicates the various running positions, acts at the same time as a lock between the controlling cylinder and reverse. The controlling cylinder is locked when the reverse is in any other position than forward or backward, and the reverse is locked except when the controlling cylinder is at the off position. The motor cut-out switches are in each controller, and a peculiar feature is, that in cutting out a motor on number 1 end, it has to be cut out on the number 2 end also. In cutting out a defective motor, cut it out on both ends.

Walker Controller, showing arc-breaking cylinder at left; also showing No. 1 motor cut-out.

BRIEF DESCRIPTION OF A STREET RAILWAY MOTOR.

The main parts which go to make up a street railway motor consists of a field, which is stationary, and a revolving armature. The field magnet is composed of an iron or a steel casting, which has a quantity of insulated wire wound around its poles. The electricity passing through this wire or field coil magnetizes the iron, creating magnetic poles. The revolving armature is composed of thin discs of soft sheet iron, firmly bolted together and fitted on a shaft, and then, after dressing up in the machine shop, is wound with a certain number of insulated wires, which are connected together, so as to form one continuous wire, passing lengthwise around the core. However, before the armature is wound, the core is thoroughly insulated with the best of insulating material, and this is considered a very important factor in the construction of an armature, as defective insulation would cause the windings to ground to the core, and then the armature would have to be stripped and

all re-wound again. The shaft upon which the armature is built furnishes both a support and means of transmitting the power of the armature by means of its pinion meshing with gear on truck axle. The windings of the armature are the most active parts, as it is in them, as well as in the field magnets, that the current arouses the force that sets and keeps in motion the wheels of the car. When a wire carrying a current is brought in front of a pole of a magnet a force is experienced which tends to drive the conductor sideways away from it, and this is exactly what takes place in an electric motor. When the windings of an armature carrying current comes in front of a pole-piece it is forced away and the armature is kept revolving around all the time as long as the current is kept applied. On the end of the armature shaft is a pinion, which meshes into a large gear wheel keyed on to truck axle, and in this way an electric car is propelled along.

TROUBLES ON THE ROAD AND HOW TO OVERCOME THE SAME.—In case of a motor dropping, by the aid of a piece of rope

G. E. 1,000—35 H. P. MOTOR—CLOSED.

G. E. 1,000—35 H. P. MOTOR—OPEN.

and a bar it can be raised and fastened up so as to run to the depot.

First of all block the wheels, and then cut out the motor that is all right, and then fasten the rope to the front of the motor. If a General Electric 800, fasten the rope to the stud of the motor which rests on the support, and then tie the rope so that when the motor comes up level the bar can be slipped through. While the motorman gives the motor a little current and the motor raises, the conductor can push the bar through loop in rope to secure the same. The motorman should be

G. E. 800 MOTOR.

very careful and not apply too much power, or the motor will rise up through the floor. The best position to be used would be the first position.

On a rheostat car, in case of it coming to a standstill, there are but a few connections that can be examined in trying to locate the trouble; however, first of all, see that your overhead switch has contact, and then try your reverse, and be sure that it is fully reversed to give a thorough contact. A great many cars have had to be pushed to the depot on account of this one simple thing. Then examine your fuse box and see that the fuse is not blown out, see that the thumb screws are tightly secured on the fuse, and while you are there try the fuse-box leads and lightning-arrester leads to see that they are not disconnected. Then try the lamp circuit to see if the lights can be lit, so as to see whether the supply wire fastened to the trolley base is burnt or broken off. If that wire is found all right the lights ought to burn, unless the car is on a dead rail, or the rails are covered with sand and dirt, and the motor ground wire had been broken, as the

light circuit must have a ground before it will burn, and the motor also must have a ground before it can be operated. Also see if the supply wire that leads to the rheostat is connected, and then see if the contact shoe is on the rheostat arm; then try the end wire on the rheostat. The end wire is the one on the inside, while the loop wire is the outer one. If the end wire on the rheostat was disconnected, the motors would not take the power until the contact shoe touched the loop segment, or if the field end connection at the motor was either burnt off or disconnected the result would be the same, and the car would not start until the power was brought to the loop connection.

After having made a careful examination of the rheostatic connections, then raise the trap and try the motor connections, and if you do not find any of them loose give them a little pull; or it may be that one of them is burnt off, and if so, you may connect temporarily with a piece of wire. At any time when making a temporary connection with a piece of wire, be sure and clear it off of the motor shell, so that it will not ground and

burn off again, and in case of your having to use small wire, do not force your car too much, for you may burn it off again. A small water pipe will not carry as much water as a larger one; and it is the same with wire—the smaller the wire, the less current it will carry. After having examined the motor connections, including the main ground wire, and have found them all right, there is but little more that could be done on the road in trying to locate the trouble. It might be a short or a broken carbon, or perhaps the carbon may be stuck in the holder; but you can easily determine this by opening the motor cover and pulling the brush hammers back and inspecting the carbons. After having done this, and you fail to locate the trouble, your only resort is to have the car towed home. If you ever have occasion to examine the carbons, do not fail to put the brush hammers down again. When you have a car equipped with two W. P. 50 motors and controlled by the rheostatic method of control, sometimes you may find that only one of the motors is working. Upon investigation you will find

frame, and then through the motors, so that when you would shut off the power with the handle in the regular way, the car would still move along. As previously stated, these conductors are insulated from the rheostat frame, but in course of time the insulation is liable to become imperfect. Of course, as long as the insulation remains perfect there is no danger of this occurring. If you ever have a car that continues to move along after you have apparently shut the power off, you should investigate at once. Throw off your overhead switch immediately. Upon investigation you will find that either the rheostat spindle is grounded to the frame, or that the cable has slipped around on the drum. This electrical trouble is one that often happens during rain or snow storms. In a case of this kind it is advised that, when you want to make a stop, you should throw off the power, except the first quarter position, and then throw off the overhead switch, leaving your handle still on the first quarter, and then when you want to start up again release your brake and throw on the overhead switch, and to increase the speed of the car operate

as usual with the controlling handle. The idea of leaving the power on the first quarter, and throwing off the overhead switch is, that by so doing you are not so liable to make mistakes, and, besides, it prevents the arcing between rheostat spindle and rheostat frame, which increases each time you throw off the power with the controlling handle, unless you throw off the overhead switch as well.

In case of trouble with controller cars, you will examine in much the same manner as with cars equipped with the old style T. H. rheostat. Of course you do not have the rheostat connections and contact shoe to examine, but you have the controller instead. If your car will not move on the first position, and will move on the second position, it will be either that one of the contact fingers has no contact, or that one of the resistance leads is either disconnected, burnt, or broken off. If both controllers work the same, it would be in resistance lead R-1 being disconnected or burnt off from resistance. Of course it might not be where it is connected to the resistance as it might be in the controller. If it is in the controller,

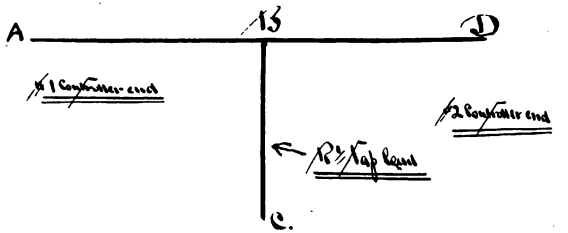


Diagram #1

then the car could be operated from the opposite controller, and would start up on the first position. You will readily see by diagram number 1, how this would affect the operation of a car.

The long line in the diagram represents the R-1 resistance wire, running from number 1 controller to number 2 controller, the entire length of the car. The short line represents the R-1 tap leading to the resistance. If there is a break at any point between A and B, then the car will not start on number 1 controller until you turn the handle to the second position, but will start up on the first position on number 2 controller. If there is a break at any point between B and D, or, in fact, anywhere between the R-1 tap and number 2 controller, the car will not start until the second position on number 2 controller. If there is a break at any point between C and B, then the car will not start from either controller until put on the second position. If the R-1 tap is burnt off where it is tapped on (marked B), then the car will not start from either controller until put on the second position, providing all the

other resistance wires are in the proper connection.

If all the resistance wires were disconnected on a K controller, the car would not start until the third position; or if R-3 wire was disconnected, it would not start until the third position, because R-3 is the negative wire leading from the resistance. If all the wires were disconnected from one of the controllers, it would not prevent operating the car by the other controller, providing that the wires were not touching each other on the other end, meaning the end that was disconnected.

If one of the motors was disconnected, or one of the leads were burnt off on a K controller, the car would not start up until reaching the fifth position on either end. The K and K-1 controllers are the same excepting the difference in the connecting board, but the wiring of the car is the same; the same number of wires are used on one as on the other.

On the K-1 the wires are straight and are fastened to the binding posts with a set screw. The connections on the K has what

is known as a crow's foot terminal soldered on to the end of the wire, and fastened to the binding posts with a set nut. These terminals are called so from their shape, which resembles a crow's foot.

The K-2 controller is the same as the K-1, excepting the difference of one more wire in the K-2, that being the R-4, and the same as the K, excepting that the binding posts are different and the R-4 resistance wire, which the K has not.

The K and the K-1 controller has seven notches each, and the K-2 has nine notches or points. With one motor disconnected on a K-2, the car would not start until the sixth position from either end, but with the resistance disconnected, would start up on the fourth position. By motor disconnected is meant that one of the wires may be burnt off, as of course if it was cut out in the regular form by means of the cut-out switch it would start out on the first position.

When you find that one of the motors is not working, have your conductor get off the car and while you apply the power let him watch to see which motor is working, which he can

easily tell by the spinning of the wheels, then cut out the defective motor so as to get power on the first position.

Number 1 motor is the motor nearest to the fuse box and number 2 motor is the farthest away. In case that you cannot open the controller cover to cut out a motor in the regular way, you can get power on the first position by closing the armature and field circuits. To do this, you will disconnect the motor connections of the defective motor, and take two short pieces of wire and connect the two brush wires together, and the two field wires together, and then your car will start up on the first position. This of course is not the proper method of cutting out the motor, but it is only shown in case you were unable to open the controller cover and were operating your car on a line with a long headway; besides the controller covers are sometimes difficult to open and if you did not have a pair of gas pliers or some similar tool, it would be impossible for you to open it. This explanation just given would be of service to you.

When you have occasion to connect the

brush leads and field leads together, as previously explained, you should not apply the power farther than the fourth position on a 7-point controller and not farther than the fifth position on a K-2, K-10 or K-11.

In case of a burnt out globe, you can light up your car by putting a copper cent in the lamp socket and then putting the lamp back again or by breaking the globe and twisting the wires together you can obtain the same results.

You should not experiment with this, however, unless you are positive that the carbon in the lamp is either broken or burnt off, because incandescent lamps are very expensive, costing about $16 per hundred.

By holding the globe between you and the light, you can easily see if the carbon or filament is broken, or at night, when a lamp burns out, the conductor can sometimes see the defective lamp flicker as the carbon is burning off, and sometimes after it is entirely burnt off it will flicker when the two ends of the filament touch each other, as the oscillation of the car will do this or by jarring of the same.

The better way to do would be to use the cent piece, because you can do it much quicker and it is more simply done; besides the burnt-out lamp with the globe broken is not worth as much as one that is not broken. Railroad companies get a rebate on new lamps when returning burnt-out lamps where the globe is not broken. When you break a globe, you have to first turn off the lamp circuit switch, and sometimes you may turn it a little too far, and instead of it being off it is again thrown on, and when you come to put in the short-circuited lamp you will receive a shock.

In case of failure to throw off the power on any style of controller, do not forget that by throwing off the overhead switch it cuts out all connections with the motor.

When a car jumps the track and the track is in proper condition, you should not fail to report the matter to the proper person, so that the car may be run in the inspection shop and examined for sprung axles, broken flanges or loose wheels, etc.

When an axle is sprung, you will easily notice it while riding on the car by the see-

saw motion it makes. You should be cautious in going over crossings and taking switches and in passing around curves, as the car is liable to become derailed.

When an axle is sprung so badly that the wheels will not stay on the track, the car should be moved ahead or back until you find a place in the wheels that fits the track, then make one of the wheels fast to the truck frame and tow or push it to the car house; or, if you cannot get a rope or a chain, place a draw bar to secure the wheel.

If it is a double motor car, cut out the motor that has the wheels locked, and use the other motor to help the car along. If you have a car that has a broken wheel flange you should operate very slowly and cautiously over curves and track that has bad joints, even if it is a straight track, and the greater the piece broken out of the wheel flange, the more cautious you should be.

If it should occur that you cannot get around a curve without derailing the car, you should back up the car a little until you get a place in the wheel that is not broken, and then either tie it with rope or chain, or put a

draw bar into it so as to lock the wheels and then push the car around. When you can get a piece of rope or chain it is much preferable to lock the wheels that way than to use a draw bar, as the draw bar is liable to become wedged in the truck frame and would be difficult to remove.

If the car is a single motor car and is standing on a curve, it would be advisable to pull it back a little off of the curve, and then when you are moving it ahead keep it moving until you get around the curve. I state this from the supposition that the motor would be on the forward end in that direction, and if it was, and you tried to push it out of a curve, you would be liable to throw the rear end off the track, as you would not be pushing it straight ahead, but partly sideways, on account of the car lifting up when being pushed, on account of not having any motor on that end.

Broken flanges are generally caused by striking curves too hard, or going over railroad crossings too fast, or running over obstacles on the track such as horse shoes, spikes, and bits of iron. When the tread of

the wheel is badly worn, generally the flange on one wheel is worn much thinner than the other, and in striking a curve hard it is very liable to break off, or in going over a crossing too fast with the car running on the flanges and not on the tread. This generally occurs where new special work has been lately put down.

With a broken axle, nothing can be done by the motorman but telephone to the proper place for the wrecking crew, and also telling the crew on the first car going in the opposite direction, so that if it is possible they can notify the inspectors of the trouble, who in turn will look out for the operation of the line in reference to maintaining headways.

With a broken gear, the only thing that you can do is to lock the wheels and get the car to the car house; or, if it happens somewhere near the end of the line, so that the car can cross over and get on the other track, you should call for the wrecking crew. In case of any unusual noise with your car, you should report it at once, so that it could be examined and the trouble located.

In case of a double-truck car getting off the

track, and you try to get it replaced, I have found it advantageous to work from the motor end, because if you work from the light end and move the car with the light end in front, the truck is liable to swing further away from the track, unless it was off in a switch in such a way that the light wheels would not climb the rail, but by backing up it would drop on the rails at the frog or switch.

When cars have charged platforms, you will generally find it on the number 1 motor end of the car. When taking on passengers you should be sure that they are safely on the car before you apply the power, or they might receive a shock. Of course you should receive assistance from the conductor in this respect. Also, when slowing down at a crossing to let persons board your car, do not apply the power until they are safely on the car, because if the platform was charged and you applied the power just as a person was taking hold of the grab handle, they would receive a shock which might result seriously and also would be a case of liability against the company.

In case you find smoke coming out of a motor you should cut out that motor at once, or it might result in serious damage to the armature. When you have a controller with a grounded cylinder and you want to operate your car from that end, you can proceed as follows: Throw off the overhead switch on the end that you want to operate from, then at the other end reverse in the backward motion, and then with the controlling handle move it around to the first safe position, and then take off the controlling handle and run the car from the front end with the overhead switch. For further details showing how to operate cars with grounded cylinders you will find the explanation further on in the book.

When cars are equipped with electric headlights, motormen should be sure and report when they find any headlight glasses broken, so that glasses may be replaced and the circuit protected from being damaged by water or snow.

A car with a grounded lightning arrester will blow a fuse when the car is standing still if both overhead switches are on. The

lightning arrester is placed underneath the car body and at the number one end on single truck cars. You will find that there are two wires connected to one end and one wire to the other end, also a small wire which is the light circuit ground wire. To be able to operate your car and prevent the blowing of fuses, you should disconnect the two wires from the lightning arrester and connect them together and operate your car in the usual manner, or else remove the main ground wire. This relates to a T. H. lightning arrester.

A motorman who takes an interest in his work will familiarize himself with the different parts of the car body and truck, so as to be able to report on the condition of the car in an intelligent manner when laying up a car in the car house.

TROLLEY POLES.

The proper care of the trolley pole depends a great deal on the motorman. A car should always be run slowly and cautiously around curves and over crossings, and the power

should always be shut off completely in going over circuit breakers.

When the conductor is collecting his fares, which he should do where there is a straight track, you should also run your car carefully, and be ready to make a stop immediately in case the trolley pole leaves the wire. If you pay strict attention to the handling of your car, you cannot fail to notice the slight check in the speed of the car when the trolley leaves the wire.

Where there are cross-overs and switches, you should exercise great care, because if the trolley fork gets caught in the frog it will either pull off the trolley stand or possibly pull the trolley wire down, thereby causing a serious delay on the line, besides the possibility of a trolley stand dropping or the trolley wire falling on some one.

When the trolley wire is pulled down, you should not leave it without leaving some one in charge, as some driver might drive his horses against it. If there was not too much of the wire down, you might be able to clear it to one side, so that the cars could clear, and in that case a good plan would be

to wait until your follower came up behind you, and then you could continue on your trip and your follower could work it the same way that you did, until the emergency crew could arrive and take charge of the fallen wire. The first thing, however, that should be done would be to telephone to your depot informing them of the trouble and the exact location. If the wire should fall on the rail, you should try and clear it away, and you could do this in safety by taking a hold of the wire with your cap or coat, which would relieve the power station from the ground held, besides keeping the cars in operation, and if you could find some pieces of wood around, you could lay the wire down on it to prevent a ground occurring again. There has never been any trolley made which will prevent the trolley wheel from leaving the wire if the car is run in a reckless manner around curves and over crossings and circuit breakers.

You should always bear in mind that a trolley is intended to follow the car and not intended to go ahead of the car, and you are never safe when backing your car without

first turning the trolley pole. When a pole has been bent by backing up without turning it you can easily see how it was done. When a trolley wheel is lost out of the fork, a good plan is to put a piece of wire through the axle holes, as this has a tendency to keep the fork a little further away from the wire than if you run it without anything, as the nearer the fork is to the wire the more liable it is to get caught in a frog or diagonal or at an anchor ear in the line.

CONTROLLER TROUBLES.

Controller troubles are probably the most frequent of any experienced with street railway cars, especially with the older types of controllers. A great deal of this trouble is caused by careless handling and in failing to move the power handle a full notch at a time, consequently causing arcing at fingers and contacts, until finally there is no contact at all or the finger and contact is blistered. The finger may get caught so that you cannot get beyond a certain position, or it may be that you will get no power on some posi-

tions, or perhaps the car will not move at all from one controller.

An inspection of the controller will probably show that one of the fingers has no contact, and a new finger will have to be put in; because, in consequence of the continual arcing between the finger and contact, there is a possibility of the temper being taken out of the tension spring of the finger.

It does not always follow that the man that has trouble with a controller is the one at fault, it may be that the motorman that had it previously caused the trouble; but when a motorman is continually having trouble with his car it is generally safe to say that he is either careless or possibly ignorant of the workings of a controller and does not follow the instructions as given him when he was first given charge of a car. A great saving for the company can be made by the careful handling of the controller. The writer has often noticed motormen applying the power so rapidly as to cause the wheels to spin around so quickly as not to give the wheels a chance to adhere to the rail until

a dry piece of rail is reached, and then the car would leap forward with a sudden movement; and in damp weather, if the rail is a little slippery, they will throw the power all the way on, and, if they have sand, they will drop it without using good judgment, and the car starts forwards with a jerk which is liable to damage the motors, especially the gears and pinions, and besides, making riding very unpleasant for passengers. If you notice a locomotive engineer in starting up with a heavy load, or on a heavy grade, or a slippery rail, you will see that he opens the valve just a little at a time, but if the wheels should commence to slip he will shut off the steam and commence to apply it again very gradually, as the wheels grip the rail, and if he uses sand he drops a little at a time, but he does not open the valve to its fullest extent and then drop sand, because if he did something would be liable to give way.

When you apply the power on the first position and the wheel slips, it stands to reason that the more power you apply, the more the wheels will continue to slip. If you apply the power gradually and give time for

the wheels to grip the rail before moving the power from one notch to another, you will find that you will make time in doing so.

On arriving at a crossing, or any part of a track that is covered with sand or dirt or water, you should let your car run over without using any power at all if possible.

There are a great many places on some lines where there are grades, and then a car can be run quite some distance without scarcely using any power at all, excepting a little to start up the car.

It is to the company's interest that you use as little power as possible in the handling of your car, and what is of interest to your employer is of interest to you also. In throwing off the power, throw it off lively but not with too much force, because you may break the rivet that rivets the cam wheel to the controlling spindle; or, if it is keyed on, it is liable to become loose.

You should never leave the car without first throwing off the overhead switch or circuit breaker, and taking off the controller handles, because it is possible for a car to start up without the power being applied

with the handles during rainy weather. This is something that very rarely occurs, but it is actually possible for such a thing to happen.

INSTRUCTIONS IN THE OPERATION OF HARDIE COMPRESSED AIR MOTOR CARS.

There are four small levers or handles to operate cars, as follows:

1st. Reversing lever.

2d. Throttle lever.

3d. Brake handle.

4th. Shut-off valve handle or "platform valve."

All these handles can be used at either end of car, and the car can be run both backwards and forwards from either end, by moving reversing lever in whichever direction it is desired to go.

Before removing handles from one end of car to the other end, it should be seen that shut-off valve (4) is closed tightly, though not with force enough to break it. The brake-valve handle must be taken off at the "lap" notch, this being the only position at which it can

be removed, unless undue force is used. The throttle valve (2) must be closed, or moved to extreme position furthest away from motorman; and the reversing lever should be moved to middle position, and put on in middle position at opposite end, after which it should be moved forward to fourth notch from the end. The other handles may then be put on their respective places and brake handle moved to "release" or "running" position; that is, looking straight toward motorman, unless motor happens to be standing on a grade, in which case brake must be left on.

To start motor, motormen will open throttle (2) by pulling lever towards him with right hand, and at same time with left hand will move brake handle (3) one position or notch to the left. Just as soon as car moves, the brake handle (3) must be returned to running position, else motor will make a slight puffing noise, which can easily be avoided if strict attention is paid to this rule; and it is only a careless or stupid motorman who will not attend to it. The shut-off valve (4) must now be

opened and left open until the throttle (2) has to be closed for any length of time, as when making a long stop or running down grade. After motor is under way the reversing lever (1) should be moved ahead, if on a level, to first notch; if on a slight up grade to second notch, and if on a rather stiff up grade to third notch. Should the motor be on a down grade the throttle may be closed and the motor allowed to "coast," and it may be necessary to use the brake in case car runs too fast. Much of this, of course, must be left to the motorman's judgment. When car is only slowed down and it is desired to go ahead, it is not necessary to use starting valve (3), but only to open throttle valve. It must be distinctly understood that it is only necessary to use starting valve (3) when starting from a state of rest, and then only until the car moves. Too much stress cannot be laid on this.

To stop car motorman will first close throttle (2), and if he sees some distance ahead where he has to stop, he will close it before reaching there, so as to "coast" as much as possible. Very great care is re-

quired in making a good easy stop, and requires some practice and good judgment. Should the brake handle be moved to "brake-on" position and kept there until full pressure accumulates in brake cylinder, it is apt to skid the wheels. The handle (3) should therefore be moved to "brake-on" position and instantly returned to "lap" position, care being taken that handle (3) is not moved back beyond "lap" position to "release" position, else it will let the brake off. Car will then make an easy stop. In case the first movement does not apply brake hard enough, the movement must be repeated. Generally speaking, the longer brake handle is left in "brake-on" position the harder will brake be applied, and two seconds at the most will apply it to its fullest extent, so that for an easy stop a quick wrist movement is required. After car is stopped, and while waiting for the bell, motorman should move his reversing lever back to fourth notch to be ready for next start, or if on a grade, to fifth notch; but never in any case further back than fifth notch.

RULES TO BE OBSERVED IN EMERGENCIES.

BRAKE FAILURE.—In case both air and hand brakes fail, motormen may stop car by pulling the reverse lever all the way back, but he should wait for next car and have his car coupled to it, in case he may not be sufficiently familiar with this method of handling car.

REDUCTION VALVE FAILURE.—Should the working pressure rise so high as to cause safety valve to blow off, motorman must close shut-off valve (4) before closing throttle valve (2), and must keep it closed until throttle valve (2) is opened again. He must be very careful about this, as it is irritating and alarming, though perfectly harmless to have safety valve blow off. In case reduction valve is very badly out of order, shut-off valve (4) must be kept closed, and the by-pass valve used. This is a small valve at side of controller stand, which can be opened by shut-off valve handle; and will enable motorman to get car home without assistance.

RUPTURE OF A PIPE.—In case motor-

man should hear a sudden loud blowing of air, as if a connection or pipe had burst, he will instantly close shut-off valve (4). Should the blowing continue, he must raise the flooring and close both header valves, using shut-off valve handle (4) for this purpose. There is a square hole at outer end of this handle which fits header valves. Motorman must hasten to do this as speedily as possible, before the air has all escaped, and he must not get alarmed at the noise and lose his head for there is positively no danger. After having closed both header valves and ascertained what pipe or connection is broken, he may re-open the header valve at the broken end, and use the air to run the car as long as it lasts, after which he will close that valve and open the other. The chances are that if he acts promptly and intelligently he can get his car home without assistance.

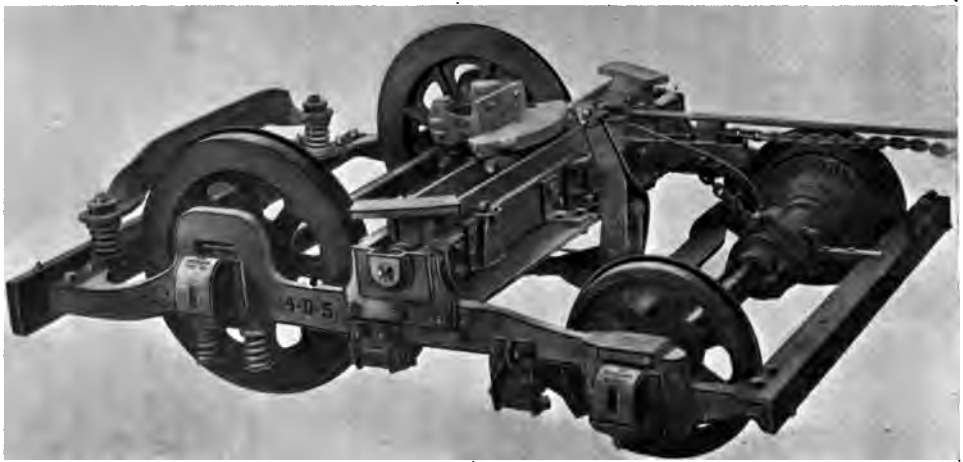
SIDE VALVE.—When charging car in power house there is a valve known as the "Side" valve because it is at one side of the car, which must be closed first thing before charging, and opened last thing after charging. In case motorman finds his car will not

go, he should therefore see if this valve is open.

Motormen must familiarize themselves with all these valves, and they will always find some one at the power house ready to explain matters and answer questions.

There is a combination pressure gauge at each end of every car, showing at all times both storage and working pressures. The long hand, which is painted black, points to the outer circle and indicates storage pressure; and the short hand, which is painted red, points to the inner circle and indicates working pressure. The automatic reduction valve controls the working pressure, allowing so much of the air in storage to pass through it to maintain working pressure. The air, however, from the storage reservoir first passes through the shut-off valve on platform before entering reduction valve; hence when reduction valve is out of order the motorman must regulate by shut-off valve, as directed above, until reduction valve is repaired.

Motormen must report defects on arriving at the power house.



THE PRICE HYDRAULIC BRAKE.

INSTRUCTIONS TO MOTORMEN FOR OPERATING PRICE HYDRAULIC BRAKE.

This brake has an operating lever, which is located close to the dash between the hand brake staff and the motor controller. To apply the brake, pull the lever slowly for an easy stop and quickly for an emergency stop, and ease off the pull on the lever slightly just before the car comes to a stop, same as is done with the hand brake.

When going up a grade do not ease off the pull entirely, but hold the brake on till ready to start the car again. If the brake is released on a grade the car will run backwards, but can be brought to a stop by applying the brake, same as when the car is running down the grade.

The lever is provided with a ratchet and pawl, but these should not be used till after the car comes to a stop and when it is desired to hold the brake on.

Before leaving the car platform always set the hand brake.

RULES FOR THE OPERATION OF THE MAGANN STORAGE AIR BRAKE SYSTEM.

The operation of the Magann Storge Air Brakes is much the same as other straight air brakes. The motorman's valves should be placed on the lap position, the motorman placing the valve handle on the valve on the end of the car he is going to operate from. When he desires to make his service stop he will turn the handle to the right until he feels the shoes grip the wheels and then place the valve on the lap position. The lap position is where it will allow him to remove the handle. If the car does not stop as quickly as desired, he will again turn the handle to the right until he feels the shoe gripping the wheels more firmly, repeating the operation again if necessary, and in the meantime, if he has skid the wheels, he can ease off the brake by turning the valve handle to the left, allowing part of the air in the brake cylinder to exhaust. He should also ease off the brake before coming to a stop by turning his valve handle to the left

and allowing the greater part of the air in the brake cylinder to exhaust before the car comes to a stop, thereby preventing the car body from lurching ahead.

INSTRUCTIONS FOR MOTORMEN IN OPERATION OF THE CHRISTENSEN STRAIGHT AIR BRAKE.

1st.—To start up the compressor, close the canopy switch. This will automatically close the governor, so that the current will pass from trolley to ground through the motor driving the compressor.

2nd.—Should the compressor refuse to work under this condition, the fuse may be blown. If so, do not put a heavier fuse in than suited for the size of the compressor. If the fuse is all right, the trouble is elsewhere, and you should try to locate it if you can readily do so; if not, you ought to report the matter to the proper authority.

3rd.—All the stop-cocks on the train pipe, except on the front and rear end of the car, should be open. When open the handle stands crosswise to the pipe, and when closed it stands parallel with it.

4th.—To cut out a standard governor, close the ¼-inch stop cock so that the T handle stands crossways with the pipe and then move the governor plunger so as to make contact and then close the circuit. The compressor can now be started and stopped by the hand switch in the canopy; but you should take care not to forget to start and stop the compressor so as to keep the pressures within the desired limits of 70 lbs. minimum and from 80 to 90 lbs. maximum.

ENGINEER'S VALVE.

LAP POSITION.—The engineer's valve, in direct control of the motorman, is made with a detachable handle which is only removable in what is known as the lap position, in which position the valve is neutral in the same manner as the main controller is by moving the reverse handle.

SERVICE APPLICATION of the brakes is effected by moving the handle of the engineer's valve to the first notch to the right. As soon as sufficiently hard pressure is brought against the wheels, the handle may be moved back into lap position, whereby

the brakes remain set at that pressure. If it is desired to set the brakes a little harder, repeat the operation. By moving back to the lap position without releasing, the handle may be removed and the brake released from the other end of the car. This feature is very valuable where the terminus is on a grade.

SLOW RELEASE OF THE BRAKES.—By moving the handle from lap position to the first notch on the left, a slower release of the brakes is effected, which release may be checked in the same way by moving the handle back to lap position, the same as in the service application of the brake.

EMERGENCY APPLICATION.—This is effected by moving the handle from lap as far as it will go to the right, in which position a large passage is afforded to allow compressed air to travel from the main reservoir to the brake cylinder, and the application of the brakes is practically instantaneous. This kind of an application should not be made except when absolutely necessary.

QUICK RELEASE.—By moving the handle from lap position to the left as far as it will

go, a quick release is effected in the same manner as a quick application by establishing a large opening from the brake cylinder to the atmosphere, whereby the pressure escapes quickly from the brake cylinder, thereby letting off the brakes in a very short space of time.

RUNNING POSITION.—The handle of the engineer's valve should always, when the brakes are not being applied or released, be on the first notch to the left or that of slow release.

BRAKE LEVERAGE.—The leverage and total pressure on the brake cylinder is so proportioned that under ordinary circumstances, with a dry rail, the wheels cannot skid. If the rail is in bad condition for stopping, the leverage and pressure being the same as under normal conditions, would probably skid the wheels if the brake cylinder be charged with the full pressure. In such instances care should be taken not to slide the wheels by not introducing too much pressure to the brake cylinder. If the wheels slide, which can be instantly felt, the

handle is moved over to slow release, letting out air until the wheels revolve, then back to lap, and release again just before the car comes to a dead stop, so as to prevent a disagreeable chuck, which follows if a car comes to a dead stop with the brakes applied.

Figure 4 shows a Christensen air brake equipment, consisting of exactly the same parts as are mounted underneath the car, with the air brake and hand brake connected up in the same manner as it is in actual operation.

INSTRUCTIONS TO MOTORMEN IN THE OPERATION OF THE MERRITT AIR BRAKE COMPANY'S SYSTEM.

STARTING CAR.—Before starting car, motorman should first ascertain, both by consulting the air gauge and making at least one brake application, that he has air pressure with which to control the movement of the car.

MOTOR COMPRESSOR.—To start the motor compressor, close the air-brake switch, when the pump will continue to run until the maximum pressure is reached.

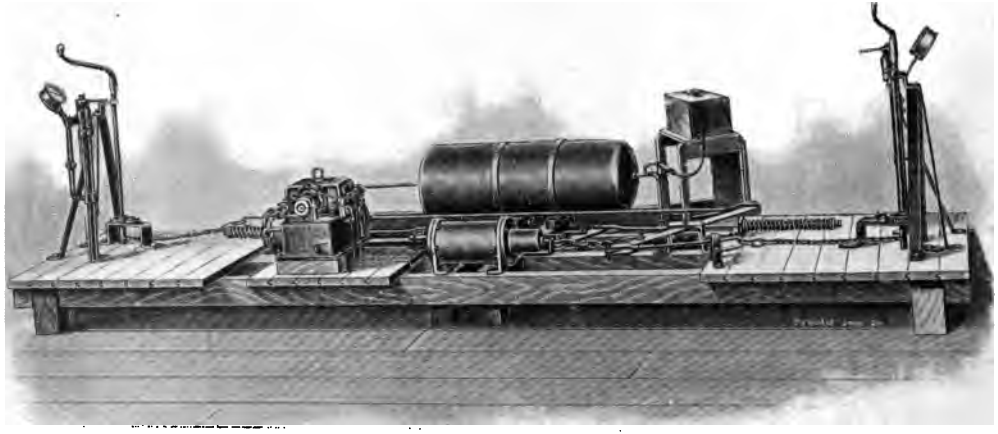


FIG. 4.—CHRISTENSEN AIR BRAKE EQUIPMENT

FUSE.—Should the compressor fail to start, see that the fuse is not blown. If it is, do not put in a larger fuse than is furnished for the motor compressor. Should the fuse again blow, in all cases report the same to the person in charge at the depot.

GOVERNOR.—Should the governor (or controller) fail at any time when on the road to work, cut it out by closing the valve in the controller pipe. See that the cross head is in contact with the terminals, and govern the air pressure with the air-brake switch, taking care to throw the switch when the maximum and minimum pressures are reached. Report same when car house is reached.

ENGINEER'S VALVE.—The engineer's valve is so constructed that the amount of brake pressure is automatically controlled according to the movement given the operating handle.

The running position of the engineer's valve is central, or when the operating handle is in the removable position.

When you want to apply the brake, pull

the handle to you until you feel the brake take hold. When you want to release the brake push the handle from you.

SERVICE STOPS.—To make a service stop, pull the handle to you until you feel the car coming to a stop, as with the hand brake, and should the car not respond as desired, a further movement of the handle will admit more air to the brake cylinder.

As the car comes to a rest, release the brake pressure as with the hand brake, until there remains in the brake cylinder only enough pressure to hold the car.

EMERGENCY STOP.—Emergency application should be made only when absolutely necessary. For an emergency stop pull the handle to you, first to bring the brake shoe in contact with the wheels, and then pull the handle to extreme travel when the full reservoir pressure will be admitted to the brake cylinder.

SLIDING WHEELS.—Should the wheels slide on account of bad rail or other causes, release the air until the wheels begin to re-

volve, and then apply the air slowly until the required pressure is obtained. Too much brake pressure will slide the wheels every time. Don't fail to see that you have air before starting the car.

Don't take the car out before trying the air brake.

Don't use larger fuse than is furnished for the motor compressor.

Don't try to start the car with the air brake set.

Don't use the air brake handle upside down, because you may leave the valve in such a position that the brake cannot be set from the other end of the car when you change ends.

Don't make more than one application when stopping the car.

Don't fail to release the brake as the car comes to a stop.

Don't apply more air when the wheels slide. Release and use less.

Don't make emergency application unless absolutely necessary.

Don't fail to put air brake handle where it belongs.

Don't leave the car for any length of time without applying the hand brake.

Don't fail to report a poor braking car to the person in charge of shop.

HAND BRAKES.

The failure of the brakes is a very serious occurrence, especially if it be that the brake chain or rod parts, or it becomes detached from the brake lever by the bolt either breaking or dropping out. The bolt referred to is the bolt that fastens the brake rod to the brake lever.

If this should happen on a crowded thoroughfare you should immediately reverse your car and apply the power, just a little, bringing the car to as near a standstill as you can, and then signal your conductor to put the rear brake on, and when the car is entirely stopped you will arrange with your conductor as to what is to be done.

In an emergency of this kind it would be well to do everthing without letting the passengers know that anything out of the ordinary had occurred. The safest way would be to have your car pushed or towed home,

and it is always safer to have the car towed than it is to have it pushed when it is convenient to do so, as then the car being operated would be in front, which is much the safer way. This rule applies to all cases when cars are disabled and cannot be operated.

If the cars are on a long headway, and the streets are not too crowded, you could, by pre-arranged signal, run your car home by the conductor operating the rear brake. Of course the motorman, in such a case, must stand ready to use the reverse and must greatly increase the distance in which to make a stop. When it becomes necessary to use the reverse, do not put on the power too fast. On a controller car the first or second, or not more than the third, position would be sufficient, and on a car equipped with a T. H. rheostat the first quarter would be the limit.

All the power that it is necessary to apply is just sufficient to turn the wheels slowly in a reverse direction to that in which the car is going. Make sure and reverse fully and follow the instructions given in regard to

putting on the power, because if you put on too much power all at once it is liable to blow the fuse, and then you surely would be in a sad plight. The only thing for you to do in such a case, meaning that when you reverse the car and the fuse blows out on account of a brake failure of any description, would be for you to throw the controller handle all the way around to the "loop," or last parallel position. In case of a broken brake chain it would only take a short while to take the brake chain from the other end and use in place of the broken one. If you ever have occasion to do this, first block the wheels so that the car would not move, and with the aid of a small monkey wrench you could make the change in a short time.

In case of a brake rod-bolt breaking or dropping out, you could use your bell-bunch if it was short enough and did not catch on the pilot board when the brake was released; this, of course, would depend on the style of the truck under your car. It might happen that the brake chains would be getting longer each trip you make and winding around the brake spindle

two or three turns, which would result in your failing to stop your car in the distance that you ought to, or perhaps not at all. You will probably find that the turn-buckles have slacked off on the brake connecting rod, and you can easily determine this by seeing whether the turn-buckle has turned away from the check-nuts or not, and if they are, you could turn the turn-buckles back up to the check-nuts and operate your car in safety. Where anything like this occurs you should report the matter as soon as possible. Of course these are things that should very rarely occur, but it is well to know how to temporarily repair them, so as to complete your trip or day's work or until you get to the depot.

In handling a car you should always know where the brake-handle will set to stop the car, and to know this you should set the handle by ratchet until you get it where it will suit you best and then let it stay there, and not let it fly off in releasing the brakes, because if you do you cannot know where the handle will set when you come to make your next stop. Besides this being an im-

portant point in the handling of your car, it is very disagreeable to passengers to have a motorman continually letting fly the brake-handle and making a disagreeable noise. This is especially disagreeable on open cars when passengers are riding on the front seat.

You should not have your brake set any when you have the power on, and in going down grade you should allow the car to coast as far as possible without using power or brakes, keeping the car under control all the while, and not running in excess of speed allowed and determined by your superintendent.

You should strive to become a good judge of distance, so that you could be able to tell pretty nearly how far the car will run after shutting off the power.

Of course, you must take into consideration as to what grade there is at that point, if any, and in this way the car can be stopped easily and everything will work nicely and smoothly. This way is far ahead of running within two car lengths of a crossing, knowing that you have to make a stop, and

then throwing off the power with a bang, jamming the brakes down in a mad struggle to stop the car, as though your life depended on it, and if any passengers are standing up in the car, throwing them all over the car, and if the brake is a good one sliding the wheels, which makes them flat.

Of course, it is expected that the conductor shall give the signal to stop in time, so that the motorman will not be required to make such a stop.

When the rail is anyway slippery at all you should run your car very cautiously, also during a heavy fog, and not take any chances whatever; and do not run up too close to a railroad crossing before commencing to get your car under control. It would be rather a poor excuse, in my estimation, to say that the rail was slippery after running into another car at a railroad crossing, knowing that there was a crossing there and the rail was slippery.

A brake that has such good leverage and is so evenly adjusted as to slide all the wheels without any unusual exertion on the part of a motorman is certainly in good condition,

and neither steam, electric, or air brakes can do any more than this; but a competent motorman will, when he feels the wheels sliding, release on the brake and work it in a see-saw motion in stopping the car.

Of course, the more slippery the rail is the more liable and the easier it is to make the wheels slide.

In regard to the use of sand, some motormen will not use one sand box full during the whole day, while another man will fill both boxes on each trip. The one man uses it only when absolutely necessary, just a little in starting up on a slippery rail and sometimes a little in stopping, in case a team cuts in on the track ahead of him, but at all stops to take on or discharge passengers, he does not use any at all. The other man uses sand without any judgment, as though the more sand he used the better motorman he was. In starting up, the car does not move fast enough for him, because instead of applying the power gradually he throws it away-around on perhaps the last position and the wheels spin around, but the car makes but little headway and then he pulls the sand

lever and lets out a lot of sand and away goes the car with a bound and a noise as though it was running over cobble stones and before he recovers himself from the sudden start the car gives, he is close to the next street crossing, and if he gets a bell to stop then down goes the brakes again with all his might, the wheels slide on the slippery rail and then he jumps for the sand lever again, and drops a lot more sand, and the car comes to a sudden stop.

When he starts up again the car has a flat wheel, he has done so much damage in five seconds that it will necessitate the taking out of the wheels and putting in another pair while the other ones are having the flat spots ground out of them, which operation takes from two to five hours, besides the enormous expense of new wheels, not counting the loss while the car is out of service. Motormen should strive to be able to tell the difference between bad rails and a bad brake and when either of these two conditions exist all precaution should be taken against collisions of any description.

The man that runs his car with ease comes

up to the end of the line on time, no accidents and no passengers wondering as to whether he was a green motorman or not, or whether there was anything the matter with the car.

If a truck driver is on the track ahead of him he rings his gong, and if the truck driver looks back the motorman gives him a pleasant nod and a smile, and at the first opportunity the driver pulls out of his way, and when these drivers get together, which they often do and compare notes, they decide that Smith, the motorman, is a jolly good fellow, and they all decide to give him a clear rail whenever they have the opportunity.

The other motorman comes up late, all confused and excited, perhaps narrowly escaped running into a coal or brewery wagon, and he is more fatigued after making one trip than the other man is after making a full days' work. His brake is out of order, or something is the matter with his car all the time, even though there are one hundred cars at the depot, and he gets a different car each day. It makes no difference to him that other men declare the car all O. K.; he has been a motorman for a certain length of time,

and he knows all about it. If a truck driver gets in his way he swears at him and calls him a lot of vile names, and the truck driver gets stubborn and drags the car for a longer distance than if Smith had been the motorman. Two or three times a week he gets a fresh supply of fuse, while other men carry the same supply all the year around. There are some motormen that are never heard of from one month's end to another, and you never know that they are working for the company at all unless you see them, as they never have any accident reports to make out, and about the only man that knows they are working is the timekeeper.

I can recall to mind quite a number of motormen that never brought in a crippled car or never broke or damaged a fender or had any accident of any description, which goes to show that, with careful handling and the exercise of good judgment, a car should rarely become disabled and accidents are possible to be avoided to a great extent.

CIRCUITS OF G. E. CONTROLLERS.

The following is the course of the current in a G. E., type K or K-1, controller, with two motors, in a series parallel connection with shunt method of operation:

FIRST POSITION.

The current passes from the trolley wire to the trolley wheel, through trolley pole to trolley stand, then through wire leading to number 1 overhead switch (M. M. switch). When switch is closed the current passes through the wire leading to number 2 overhead switch (M. M. switch); and when switch is closed the current passes through wire leading to and connecting with the fuse box (cut-out box), leaving same and passing through wire which connects with lightning arrester. When a T. H. lightning arrester is in circuit the current passes in at a point marked A, passing through blow-out magnet coil, leaving at a point marked B; then passing through a wire connecting with wire in cable marked T (meaning trolley). The current passes through this wire, which connects with terminals marked T on connec-

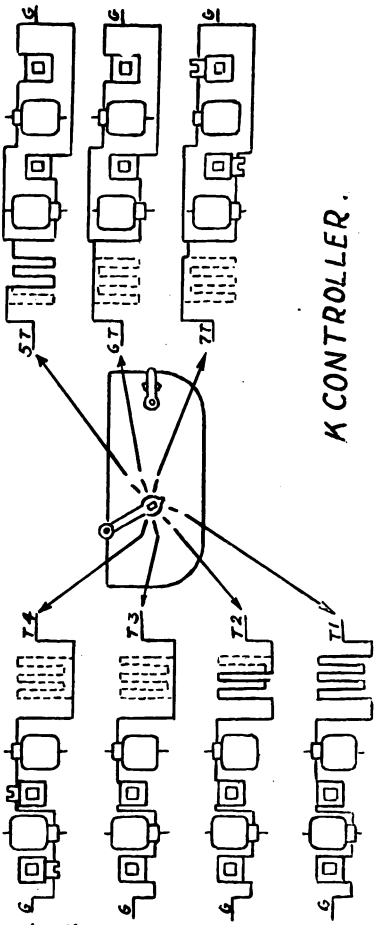


Diagram showing the course of current through the resistance on each position of controller, the unbroken line showing the amount of resistance in, and the broken line showing the amount cut out.

tion board of each controller, and also in connection with each blow-out magnet coil of controller. The current then passes through blow-out magnet coil, when in operation, and then passes through a wire connecting with the top contact wiper or finger of each controller. When controller cylinder is thrown to the first position the current passes through wire marked R-1 which is the first wire connecting with the rheostat or resistance, leaving the rheostatic circuit through wire marked R-3, connecting with terminal marked R-3 on connection board of each controller—that connecting with wire marked number 19, which is the main circuit wire of number 1 motor's entire circuit; that connecting with the bottom contact wiper or finger of reverse switch or reverse cylinder. When reversing switch or cylinder is thrown ahead for the forward motion of the car the current passes to and leaves at the 2nd contact wiper up on the reverse switch, passing through wire marked A-1, which is the wire connecting with the brush-holder of number 1 motor's armature circuit. The current then passes through the

armature circuit, leaving at opposite brush-holder, passing through wire marked AA-1, which connects with the 3rd contact wiper up on reverse switch—the current leaving at the 4th contact wiper up on reverse switch then passing through wire marked F-1, which is the wire connecting with the field circuit of number 1 motor, which is composed of one, two or four fields, leaving the same and passing through wire marked E-1, which is the ground end wire of number 1 motor's entire circuit; that leading to and connecting with the centre bar of number 1 motor cut-ont switch. The current then passes through wire and connects with the contact wipers marked E-1, and that in connection with (through) cylinder to wire marked number 15, which is the main circuit wire of number 2 motor's entire connection; that connecting with the 5th contact wiper up on reverse switch, the current leaving at the 6th contact wiper up on the reverse switch, passing through wire marked A-2, which is the wire connecting with the brush holder of number 2 motor's armature circuit; the current then passes through

armature circuit; leaving at opposite brush holder, passing though wire marked AA-2, which connects with the seventh contact wiper up on reverse switch, the current leaving at the eighth contact wiper up on the reverse switch, then passing through wire marked F-2, which is the wire connecting with the field circuit of number 2 motor, which is composed of one, two or four field coils, leaving same, and passing through wire marked E-2, which is the ground-end wire of number 2 motor's entire connection, that leading to and connecting with the main ground wire marked (G) at motor. The above is the complete circuit of two motors, in series, in connection with G. E. Controller, type K or K–l, on first position.

SECOND POSITION.

When using the second position the two motors are still held in series, the circuit being the same as on the first position, but with this exception, that instead of the current passing through wire R-1, it passes through wire marked R-2, which leads to and connects with the rheostatic circuit. On

this position, a part of the resistance is cut out, leaving about half of the number of panels of resistance in connection with motor circuit, which allows an increased speed held with motors by an increase of current to motor terminals.

THIRD POSITION.

When using the third position the two motors are still held in series, the circuit being the same as on the first and second positions, but with this exception, that there is no rheostatic connection whatever with motor circuit, the current being direct to motor terminals, which allows a still greater speed held with motors over and above that of the second position by an increase of current to motor terminals.

FOURTH POSITION.

When using the fourth position the two motors are still held in series, as on the preceding positions, and without exterior resistance, but with this exception, that the field circuits are shunted, the current shunted from number 1 motor's field circuit is carried to the ground through number 2 motor's armature circuit,

the current shunted from number 2 motor's field circuit is carried to the ground through the main ground wire terminal in the controller; the shunting of the field circuit of motors number 1 and 2 decreases the field strength, which allows an increased current at armature terminals, which gives an added increase of speed to the armatures.

FIFTH POSITION.

When using the fifth position the two motors are placed in parallel or multiple, with about one-half of rheostatic panels of resistance in connection with same, the current passing to rheostat through wire marked R-2. On this position the wire marked E-1, which is ground end wire of number 1 motor's entire connection is placed in connection by the controlling cylinder to main ground wire in controller. The circuit of number 2 motor is in connection with that of number 1 motor's main circuit wire marked number 19, that connecting with wire marked number 15, which is number 2 motor's main circuit wire; the ground end wire of number 2 motor's circuit, which

is wire marked E-2, is still held in connection with main ground wire at motor.

SIXTH POSITION.

When using the sixth position the two motors are still held in parallel or multiple as on the fifth position, but with this exception, there being no exterior resistance, the current being direct to motor terminals, the current passing to number 1 motor's circuit through wire marked number 19 in controller, the current passing to number 2 motor's circuit through wire marked number 15 simultaneously. Wires marked number 15 and number 19 are held in circuit by the connection of the contact wiper marked R-4.

SEVENTH POSITION.

When using the seventh position the two motors are still held in parallel or multiple as on the sixth position, but with this exception, the field circuit being shunted, the current shunted from number one motor's field circuit is carried to the ground through the main ground wire terminal in controller, the current shunted from number 2 motor's

field circuit is carried to the ground through the main ground wire terminal in the controller.

EXPLANATORY NOTE.

When changing the controlling cylinder from a series to a parallel connection, the number 2 motor's circuit is entirely cut out when midway between the fourth and fifth positions, but when the two motors are placed in multiple the connection is not made in full until on the fifth position. The shunt resistance used in connection with motors are usually tapped from the field leads on the positive side of the field circuit. The ground ends of shunt resistance are placed in connection with controllers by wires marked L-1 and L-2. The safe running positions or continuous points on a type K or K-1 controller are 3, 4, 6, and 7, and the unsafe positions are 1, 2, and 5, which are rheostatic or resistance points. The safe running positions are designated by the long raised bars on dial plate on cap of controller and the rheostatic, or resistance points, are designated

by the short-raised bars on the dial plate. The longer of the shorter bars are on the series connection positions of controller, while the shortest of the shorter bars are on the multiple positions of the controller.

CIRCUITS OF G. E. CONTROLLER TYPE K-2.

The following is the direction of the current in connection with a G. E. controller type K-2:

With two motors in a series parallel connection with shunt method of operation.

FIRST POSITION.

The current passes from the trolley wire to the trolley wheel, through trolley pole to the trolley stand, then through wire leading to number 1 overhead switch (M. M. switch). When switch is closed the current passes through the wire leading to number 2 overhead switch (M. M. switch); and when switch is closed the current passes through wire connecting with the fuse box (cut-out box), leaving same and passing through wire connecting with lightning arrester.

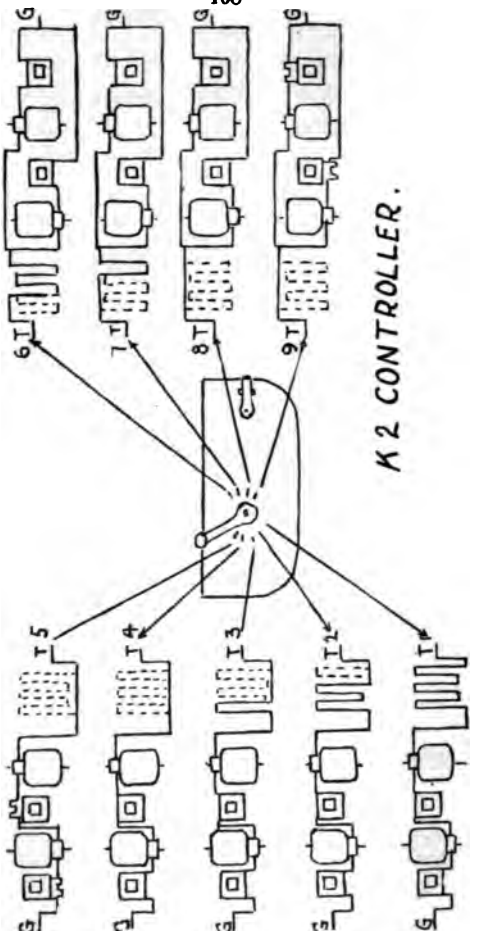


Diagram showing the course of current through the resistance on each position of controller, the unbroken line showing the amount of resistance in, and the broken line showing the amount cut out.

When a T. H. lightning arrester is in circuit the current passes in at a point marked A, passing through blow-out magnet coil, leaving at a point marked B, then passing through a wire which connects with wire in cable marked T (meaning trolley). The current passes through this wire, which connects with terminals marked T on connection board of each controller and also in connection with each blow-out magnet coil of controller. The current passes through blow-out magnet coil when in operation and then passes through wire connecting with the top contact wiper or finger of each controller. When controller cylinder is thrown to the first position the current passes through a wire marked R-1, which is the first wire connecting with the rheostat or resistance, leaving the rheostatic circuit through wire marked R-4, which connects with terminal marked R-4 on connection board of each controller, that connecting with wire marked number 19, which is the main circuit wire of number 1 motor's entire circuit, that connecting with the bottom contact wiper or finger of reverse switch or

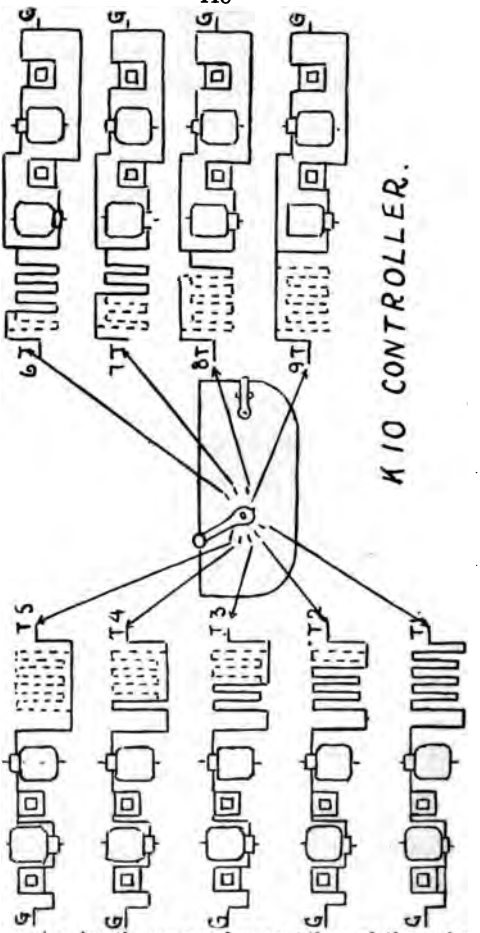


Diagram showing the course of current through the resistance on each position of controller, the unbroken line showing the amount of resistance in, and the broken line showing the amount cut out.

wire of number 1 motor's entire circuit; that connecting with the bottom contact wiper or finger of reverse switch or reverse cylinder. When reversing switch or cylinder is thrown ahead for the forward motion the current passes to and leaves at the second contact wiper up on reverse switch passing through wire marked A-1, which is the wire connecting with the brush holder of number 1 motor's armature circuit; the current then passes through armature circuit, leaving at opposite brush holder, passing through wire marked AA-1, which connects with the third contact wiper up on reverse switch, the current leaving at the fourth contact wiper up on reverse switch, then passes through wire marked F-1, which is the wire connecting with the field circuit of number 1 motor, which is composed of 1, 2, or 4 field coils, leaving same and passing through wire marked E-1, which is the ground-end wire of number 1 motor's entire circuit. That leading to and connecting with the right hand bar of number 1 motor's cut-out switch; the current then passes through a wire and connects with the contact wipers marked

E-1, and those in connection with (through cylinder) wire marked number 15, which is the main circuit wire of number 2 motor's entire circuit, that connecting with the fifth contact wiper up on reverse switch, the current leaving at the sixth contact wiper up on the reverse switch passing through a wire marked A-2, which is the wire connecting with the brush holder of number 2 motor's armature circuit. The current then passes through armature circuit, leaving at opposite brush holder, passing through wire marked AA-2, which connects with the seventh contact wiper up on reverse switch, the current leaving at the eighth contact wiper up on reverse switch, then passing through wire marked F-2, which is wire connecting with the field circuit of number 2 motor, which is composed of 1, 2, or 4 field coils, leaving same and passing through a wire marked E-2, which is the ground-end wire of number 2 motor's entire circuit, that leading to and connecting with the main ground wire marked (G) at motors.

The above is the complete circuit of two motors in series in connection with a G. E.

controller types K-10 or K-11 on the first position.

SECOND POSITION.

When using the second position the two motors are still held in series, the circuit being the same as on the first position, but with this exception, that instead of the current passing through the wire marked R-1 it passes through the wire marked R-2, which leads to and connects with the rheostatic circuit.

On this position a portion of the resistance is cut out, leaving about three-fourths in connection with motor circuits, which allows an increase of speed held with motors by an increase of current to the motor terminals.

THIRD POSITION.

When using the third position the two motors are still held in series, the circuit being the same as on the first and second positions, but with this exception, that instead of the current passing through the wires marked R-1 and R-2 it passes through a wire marked R-3, which leads to and connects with the rheostatic circuit. On this

position a still larger portion of the resistance is cut out, leaving about one half of the resistance in connection with motor circuits, which also allows an increase of speed held with motors over and above that of the second position by an increase of current to the motor terminals.

FOURTH POSITION.

When using this position the two motors are still held in series, the circuit being the same as on the first, second and third positions, but with this exception, that instead of the current passing through wires marked R-1, R-2 or R-3, it passes through a wire marked R-4, which leads to and connects with the rheostatic circuit. On this position a still larger portion of the resistance is cut out, leaving about one-fourth in connection with the motor circuits, which also allows an increase of speed held with motors over and above that of the third position by an increase of current at the motor terminals.

FIFTH POSITION.

When using the fifth position the two motors are still held in series, the circuit being

the same as on the first, second, third, and fourth positions, but with this exception, that there is no rheostatic connection whatever with the motor circuit; the current being direct to motor terminals, which allows a still greater increase of speed held with motors over and above that of the fourth position by an increase of current to motor terminals.

SIXTH POSITION.

When using the sixth position the two motors are placed in parallel or multiple with about three-fourths of the resistance in connection with the same, the current passing to rheostat or resistance through the wire marked R-2. On this position the wire marked E-1, which is ground-end wire of number 1 motor's entire connections, is placed in connection by the controlling cylinder to main ground wire in controller. The circuit of number 2 motor is in connection with that of number 1 motor's main circuit wire marked number 19, that connecting with the wire marked number 15, which is number 2 motor's main circuit wire.

The ground-end wire of number 2 motor's circuit is always in connection with the main ground wire at the motor.

SEVENTH POSITION.

When using the seventh position the two motors are still held in parallel or multiple, as on the sixth position, but with this exception, that about one-half of the resistance is placed in circuit with same, the current passing through rheostat, or resistance, through a wire marked R-3, which allows an increase of current at motor terminals and gives an added increase speed to armatures.

EIGHTH POSITION.

When using the eighth position the two motors are still held in parallel or multiple, as on the sixth and seventh positions, but with this exception, that about one-fourth of the resistance is placed in circuit with the same, the current passing to rheostat or resistance through a wire marked R-4, which allows an increase of current at the motor terminals and gives an added increase of speed to armatures.

NINTH POSITION.

When using this position the two motors are still held in parallel or multiple, as on the sixth, seventh and eighth positions, but with this exception, that all the exterior resistance being cut out, the current being direct to motor terminal, and then passing to number 1 motor circuit through wire marked number 19 and then passing to number 2 motor's circuit through wire marked number 15 simultaneously.

Wires marked number 19 and number 15 are held in circuit by the connection of the contact wiper marked R-5.

When changing contróller cylinder from a series to a parallel connection, the number 2 motor's circuit is entirely cut out when midway between the fifth and sixth positions, the same as that of a circuit with a G. E. type K-2 controller. The two motors are placed in multiple when the controller is thrown to the sixth position, as on the type K-2 controller.

The safe running positions of a G. E. type K-10 or K-11 controller are the fifth and ninth positions. The unsafe running posi-

NO. 8,340.—G. E. K-11 CONTROLLER—SHOWING SWING POLE PIECE THROWN BACK, AND CONTACT FINGERS EXPOSED.

G. E. K-11 CONTROLLER SHOWING SWING POLE PIECE CLOSED FOR OPERATION.

tions are 1, 2, 3, 4, 6, 7 and 8, which are rheostatic, or resistance points or positions. The safe running positions are designated by the long raised bars on the dial plate on cap of controller, and the rheostatic or resistance points are designated by the short raised bars on the dial plate.

REVERSING SWITCH.

The reversing switch or cylinder of a G. E. controller is constructed of wood or some other insulating material and is cylindrical in shape. The contact plates, of which there are 16 in number, are mounted upon this cylinder for the purpose of causing direction with the armature or armatures in connection, with same, eight of which are for the forward motion and eight for the backward motion. When using the forward motion, eight of the contact plates of the reverse switch are connected in pairs, beginning at the bottom of the reverse switch. The connections are made usually by a heavy wire, about number 4 size, and are embedded in the wood or insulating material of the switch. In this connection of both motors there are

four pairs of contact plates required, the first two of which from bottom of switch upward represent number 1 motor's connections, while the third and fourth pair, counting from the bottom, represent number 2 motor's connection.

The bottom contact wiper of the first pair is the number 19 wire connection, and the second contact wiper of this pair is the A-1 lead connection. The third contact wiper up on the reverse switch, which is the first contact wiper of the second pair, is the AA-1 lead connection. The fourth contact wiper up, which is the second contact wiper of the second pair, is the F-1 lead connection. The fifth contact wiper up on reverse switch, which is the first wiper of the third pair, is the number 15 wire connection. The sixth contact wiper up on the reverse switch, which is the second contact wiper of the third pair, is the A-2 lead connection.

The seventh contact wiper up on the reverse switch, which is the first contact wiper of the fourth pair, is the AA-2 lead connection.

The eighth contact wiper up on the reverse

switch, which is the second contact wiper of the fourth pair, is the F-2 lead connection.

When reversing for a backward motion, the other eight contact plates are placed in connection with contact wipers and are connected in pairs the same as for the forward motion, but with this exception, that they are in alternate connection, that is, the first and third are in connection with each other, and also the second and fourth, which comprises number 1 motor's connection, also the fifth and seventh, are in connection with each other, and the sixth and eighth contact plates are in connection, which comprises number 2 motor's connection.

The first and third contact plates represent, respectively, the connection of number 19 wire and the AA-1 armature lead, and the second and fourth contact plates represent the connection of the A-1 armature lead and the F-1 field lead.

The fifth and seventh contact plates represent, respectively, the connection of number 15 wire and AA-2 armature lead, and the sixth and eighth contact plates represent the

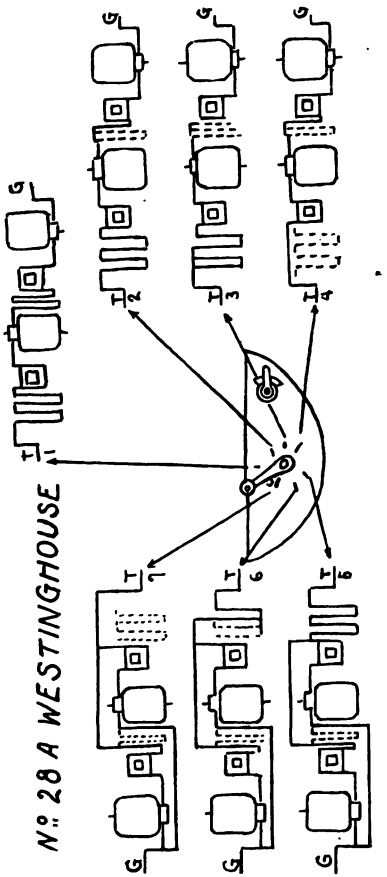


Diagram showing the course of current through the resistance on each position of controller, the unbroken line showing the amount of resistance in, and the broken line showing the amount cut out.

connection of the A-2 armature lead and F-2 field lead.

The above is the complete connection for the forward and backward motion of the reverse switch in a G. E. type K, K-1, K-2, K-10 and K-11 controller, and is correct when applied to either controller of a car.

WESTINGHOUSE 28-A CONTROLLER.

The direction of the current in connection with a Westinghouse 28-A controller is identical to that of the General Electric up to and including the trolley contact wiper in controller.

When the controlling cylinder is on the first position, the current passes from the trolley contact wiper to the contact wiper marked R-1, that in connection by wire to diverter number 2, leaving said diverter, rheostat, or resistance circuit at terminal marked R-3, that in connection by wire to arc coil in controller. The negative lead of this coil being in connection with the lower right-hand corner binding post of number 1 motor's cut-out switch, that in connection with the top right-hand

binding post of number 1 motor's cut-out switch, that being in connection with the left-hand binding post of contact wiper of reverse switch (when speaking of the left-hand binding post of the reversing switch); this is to be taken from the exact centre of reversing switch disc; this in connection with the binding post marked F-1+; that in connection with the cable lead marked F-1—, which is the wire connecting with number 1 motor's field circuit, leaving same through wire marked F-1+; that in connection with terminal in controller marked marked F-1—; that in connection with binding post of reverse switch marked F-1—; that in connection with binding post marked A-1+; that in connection with wire in cable marked A-1+, which is the wire connecting with the positive brush-holder of number 1 motor's armature circuit, leaving the same at the opposite brush-holder, and then through wire marked A-1—, which connects with terminal in controller marked A-1—, and that in connection with the top left-hand binding post of number 1 motor's cut-out switch; that in connection with the bottom left-hand binding

post of number 1 motor's cut-out switch; that in connection with the terminal and contact wiper marked R-4. The current at this point passes through a wire marked R-4, which is in connection with number 1 diverter, leaving same at terminal marked R-5, which is in connection with (through cylinder) the main circuit wire of number 2 motor's entire connection; that in connection with the lower left-hand binding post of number 2 motor's cut-out switch; that in connection with the top left-hand binding post of number 2 motor's cut-out switch, that in connection with the right-hand binding post of reverse switch. The current then passes to the binding post marked F-2+; that in connection with wire in cable marked F-2—, which is the wire connecting with number 2 motor's field circuit, leaving same at terminal and through wire marked F-2+, connecting with wire in controller marked F-2—; that in connection with through reverse switch to binding post marked A-2+. The current then passes through wire marked A-2—, which connects with the positive brush holder of number 2

motor's armature circuit, leaving same at opposite brush holder through wire marked A-2+, which leads to and connects with the main ground wire at motor.

The above is two motors in series on first position, with Westinghouse 28-A controller in connection with number 46 diverters. (Diverters in this system means the rheostat or resistance.)

SECOND POSITION.

When using the second position the two motors are still held in series, as on the first position, the course of the current being the same but with this exception, that the number 1 diverter is cut out of circuit, with current passing through number 2 diverter, as on the first position, which allows an increase of current to motor terminals, giving an increased speed to armatures.

THIRD POSITION.

When using the third position the two motors are still held in series, as on the first and second positions, the course of the current being the same; but with this exception

—that about one-half of panels of number 2 diverter is cut out, the current passing to diverter through wire marked R-2, which allows an increase of current to motor terminals giving an increase of speed to armature.

FOURTH POSITION.

When using the fourth position, the two motors are still held in series as on the first, second, and third positions, the course of the current being the same, but with this exception, that both of the diverters are cut out of the circuit, the current being direct to motor terminals, giving a still greater increase of speed to armature, this is the first direct or safe running position on controller, marked one-half speed on dial plate.

FIFTH POSITION.

When using the fifth position, the two motors are placed in a parallel or multiple connection, with the number 2 diverter in connection with same. On this position the diverter wires, marked R-4 and R-5, act as a ground connection for number 1 motor's circuit, they being in connection with the main

ground wire in controller. The number 2 motor's circuit is held in connection by the main circuit wire of number 1 motor's connection.

SIXTH POSITION.

When using the sixth position, the two motors are still held in multiple, the course of current being the same as on the fifth position, but with this exception, that about one-half of the panels of number 2 diverter is cut out of circuit, the current passing to diverter through wire marked R-2, which allows an increase of current to motor terminals, giving an increased speed to armatures.

SEVENTH POSITION.

When using the seventh position, the two motors are still held in multiple, the course of the current being the same as on the fifth and sixth positions, but with this exception, the entire diverter circuit being cut out, the current being direct to motor terminals, which allows the maximum speed of armature. This is the second direct or safe running position on controller, marked full speed on dial plate.

EXPLANATORY.

When using the reverse switch the polarity of motors are changed on field circuit, which allows the backward motion or movement of the car. The polarity of armature circuit remaining intact either on the forward or backward motion.

HOW TO FORM A CONNECTION TO OPERATE A CAR WITHOUT A CONTROLLER.

To form this connection with resistance in circuit for a forward motion of the car on the end that this connection is made proceed as follows:

Place the wire marked T in connection with wire marked R-1, and then place the wire marked R-3 if on a type K or K-1 cable, or wire marked R-4 if on a type K-2 cable, or wire marked R-5 if on a type K-10 or K-11 cable, in connection with wire marked A-1, and then place wire marked AA-1 in connection with wire marked F-1, and then place wire marked E-1 in connection with wire marked A-2, and then place wire marked

AA-2 in connection with wire marked F-2. The E-2 wire is in connection with the main ground wire and completes the circuit of two motors in a series connection.

To form a connection without resistance in circuit proceed as follows:

Place wire marked T in connection with wire marked A-1, and then place wire marked AA-1 in connection with wire marked F-1, and place wire marked E-1 in connection with wire marked A-2; then place wire marked AA-2 in connection with wire marked F-2. This connection places two motors in series without resistance. In both of the aforementioned the motors are controlled by means of the main motor switches, throwing on to start and throwing off to stop movements of the car.

To form a connection with the resistance in circuit for a backward motion of car on the end that this connection is made proceed as follows:

Place the wire marked T in connection with the wire marked R-1, and then place the wire marked R-3, if on a type K or K-1 cable, or wire marked R-4 if on a type K-2 cable or

wire marked R-5 if on a type K-10 or K-11 cable, in connection with wire marked AA-1, and then place wire marked A-1 in connection with wire marked F-1; and then place wire marked E 1 in connection with wire marked AA 2, and then place wire marked A-2 in connection with wire marked F-2. The E-2 wire is in connection with the main ground wire and completes this circuit of two motors in series.

To form a connection without resistance in circuit, proceed as follows:

Place wire marked T in connection with wire marked AA-1, and place wire marked A 1 in connection with wire marked F-1; then place wire marked E-1 in connection with wire marked AA-2; then place wire marked A-2 in connection with wire marked F-2. The E-2 wire remains intact, as previously stated. In both of the aforementioned connections the motors are controlled by means of overhead switch, as previously stated.

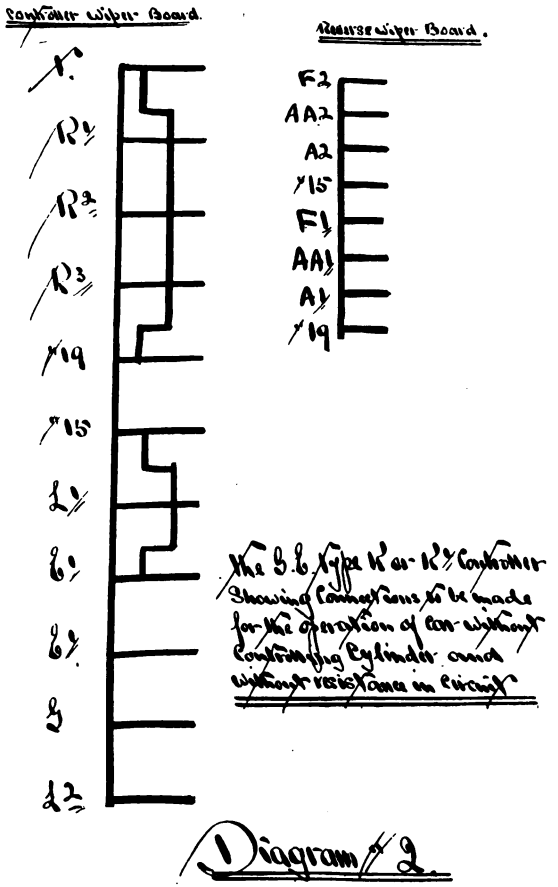
TO OPERATE CAR WITH GROUNDED CONTROLLER CYLINDER.

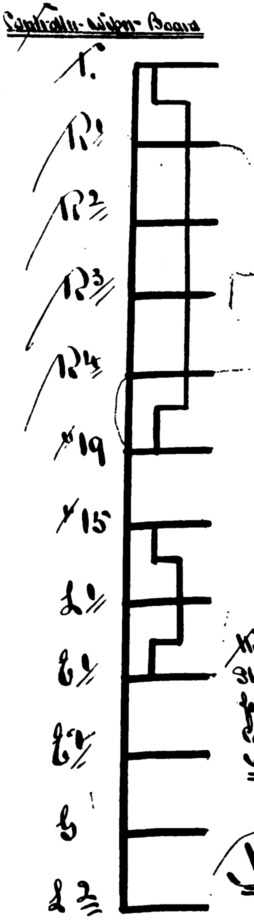
To make connection for operating motors without the use of the controller cylinder or resistance, for street operation, proceed as follows:

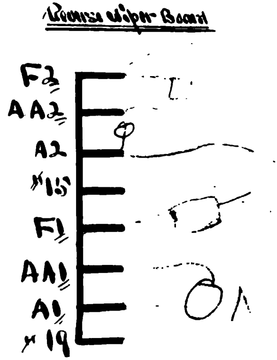
Connect a wire to top contact wiper in controller which is trolley, and then connect to contact wiper marked number 19; then take a second wire and connect the contact wiper marked number 15 to contact wiper marked E-1. The aforementioned connection places the two motors in a series connection, and motors can be operated in either direction with the reverse switch placed in connection, operating circuit by use of overhead switch, throwing on to start and throwing off to stop the movements of car. See Diagrams 2, 3 and 4.

To operate motors without use of controller cylinder with resistance in connection proceed as follows:

To make connection to place all resistance in circuit with motor circuit connect the contact wiper marked T to contact wiper

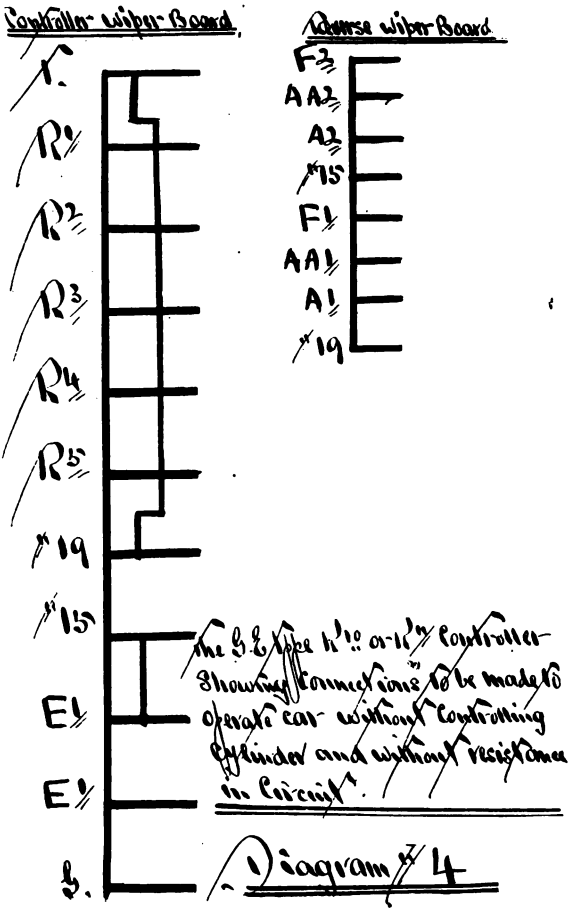

Condenser Wiper Board.
Reverse Wiper Board.
F2
AA2
A2
F1
AA1
A1
Diagram № 2.





The G.E. Type K7 Controller showing connections to be made for the operation of car without controlling cylinder and without resistance in circuit.

Diagram #3


Controller wiper Board.
C.
R½
R2½
R3½
R4½
R5½
#19
#15
E1½
E½
B.
Reverse wiper Board
F3½
AA2½
A2½
#15
F1½
AA1½
A1½
#19
The G.E. type K10 or 12 Controller
Showing connections to be made to
operate car without Controlling
Cylinder and without resistance
in Circuit.
Diagram #4

marked R-1 with a piece of wire; then connect contact wiper marked number 15 to contact wiper marked E-1 with wire. This connection places the two motors in series with the entire exterior resistance in circuit, and motors can be operated in either direction by aid of reverse switch in connection, the circuit being governed by main motor switch, throwing on to start and throwing off to stop. See Diagrams 5, 6 and 7.

To operate car with grounded reverse cylinder forward motion. In forming a connection to operate two motors without the use of reverse cylinder proceed as follows:

To make a connection for forward motion with either controller connect contact wipers number 19 and A-1 together with wire, connect contact wipers marked AA-1 and F-1 together with wire, connect contact wipers marked number 15 and A-2 together with wire, and connect contact wipers marked AA-2 and F-2 together with wire. This connection allows the motors to be operated either in the series or parallel connection with controlling cylinder. See Diagram 8.

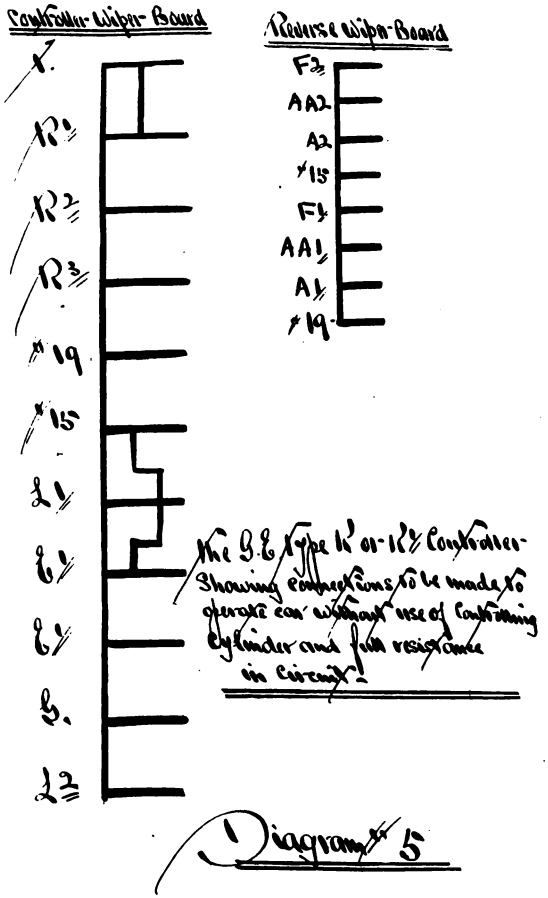
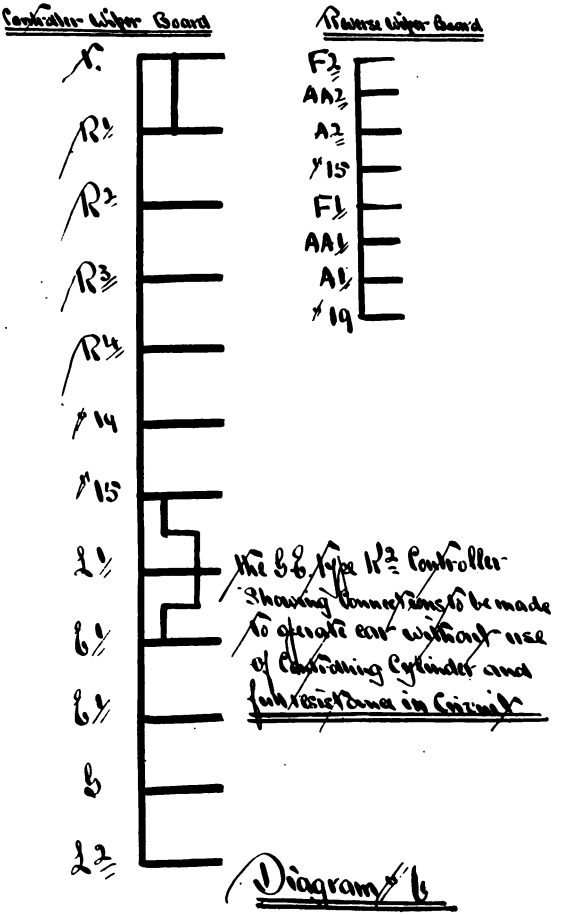
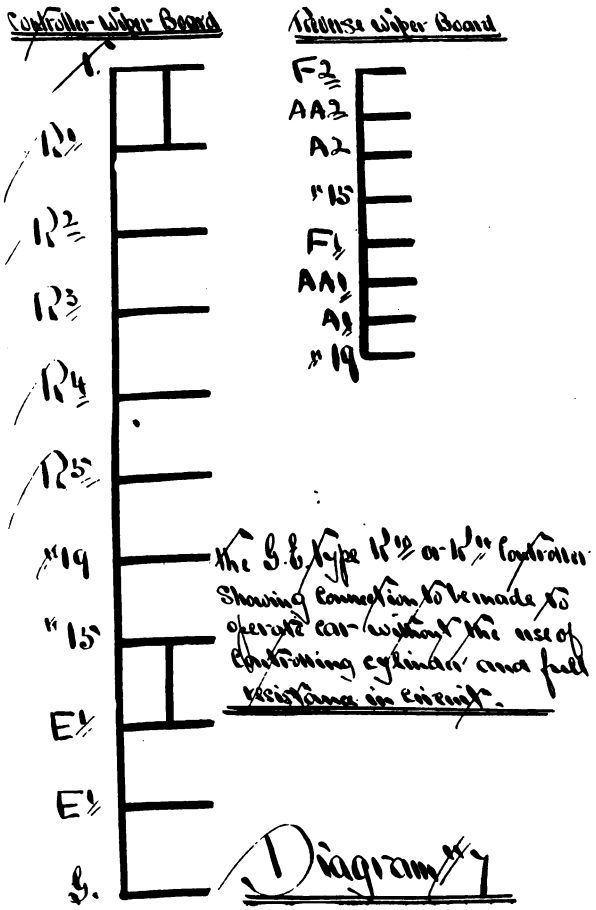
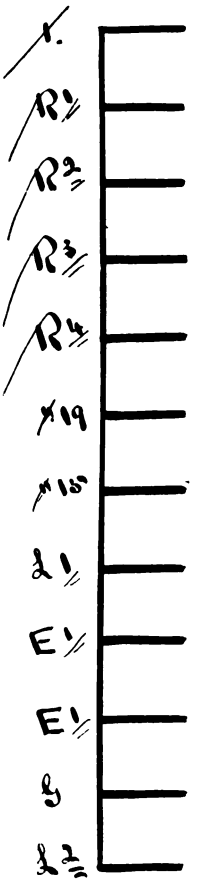

Controller-Wiper-Board
Reverse Wiper-Board
F2
AA2
A2
F1
AA1
A1
The B.B Type K or K2 Controller
Showing connections to be made to
operate car without use of Controlling
Cylinder and full resistance
in circuit.

Diagram 5


Controller Wiper Board
Reverse Wiper Board
F2
AA2
A2
#15
F1
AA1
A1
#19
K
R1
R2
R3
R4
#14
#15
L1
L
L1
B
L2
The BB Type K2 Controller
showing connections to be made
to operate car without use
of Changing Cylinder and
Auxiliaries in Circuit
Diagram #16


Controller Wiper Board
Reverse Wiper Board
F2
AA2
A2
" 15
F1
AA1
A1
" 19
1.
R1
R2
R3
R4
R5
" 19
" 15
E1
E2
B.
The G.E. type K11 or K12 Controller showing connection to be made to operate car without the use of Shunting cylinder and full resistance in circuit.
Diagram 7

Controller Wiper Board



Reverse Wiper Board

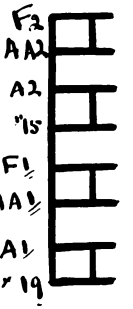


Diagram #8.

Backward motion. To make connection for a backward motion with either controller proceed as follows:

Connect contact wipers marked number 19 and AA-1 together with wire, connect contact wipers marked A-1 and F-1 together with wire, connect contact wipers marked number 15 and AA-2, together with wire, and connect contact wipers marked A-2 and F-2, together with wire; this connection allows the two motors to be operated either in a series or parallel connection with controller cylinder. See Diagram 9.

To operate number 1 motor, without controller cylinder and without resistance, proceed as follows:

Connect the contact wiper marked T with contact wiper marked number 19, then connect contact wiper marked E-1 to contact wiper marked G, which is ground. The above connection forms a complete circuit of number 1 motor's connection and motor can be operated in either direction with the reverse switch placed in connection, operating circuit by use of main motor switch. See Diagrams 10, 11 and 12.

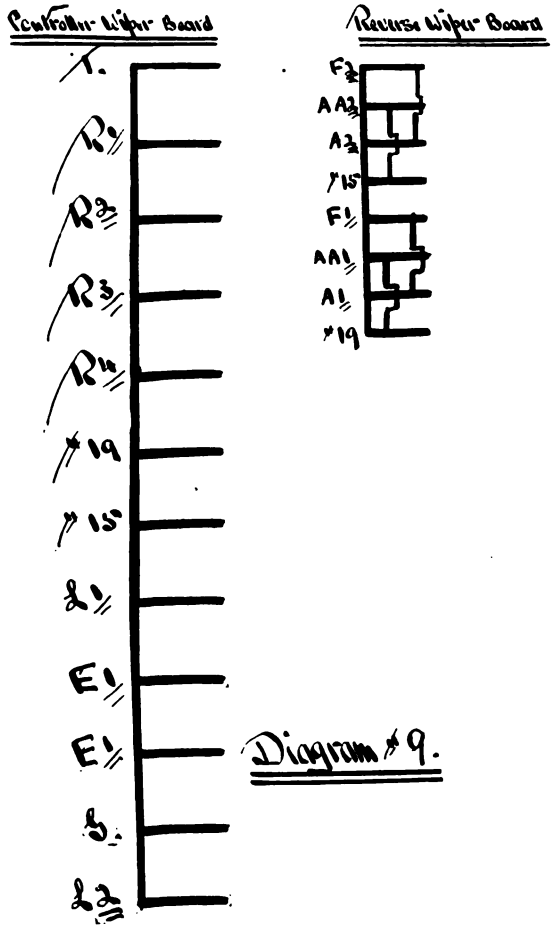

Controller Wiper Board
1.
R½
R2½
R3½
R4½
*19
*15
L1½
E1½
E1½
5.
L2½
Reverse Wiper Board
F2½
AA2½
A2½
*15
F1½
AA1½
A1½
*19

Diagram #9.

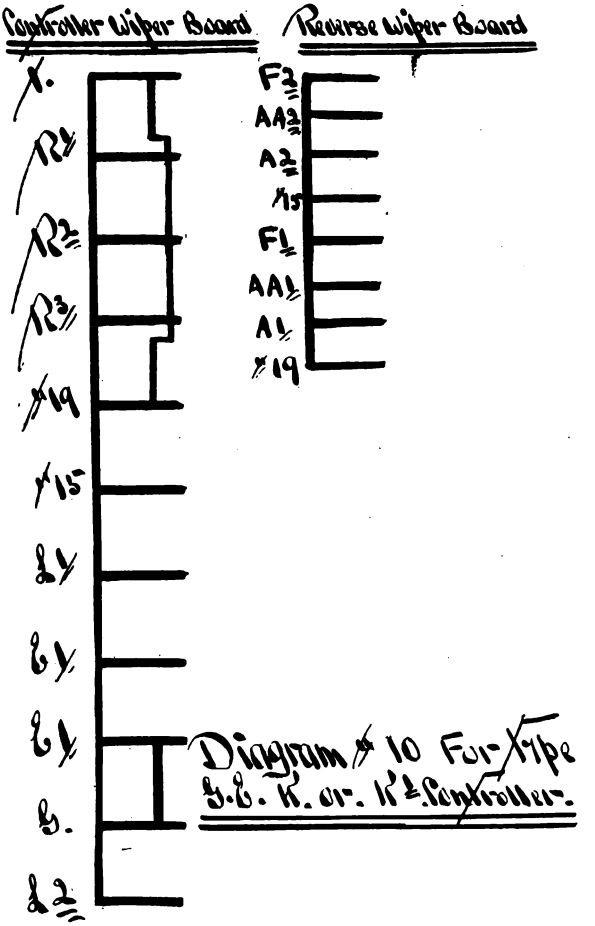
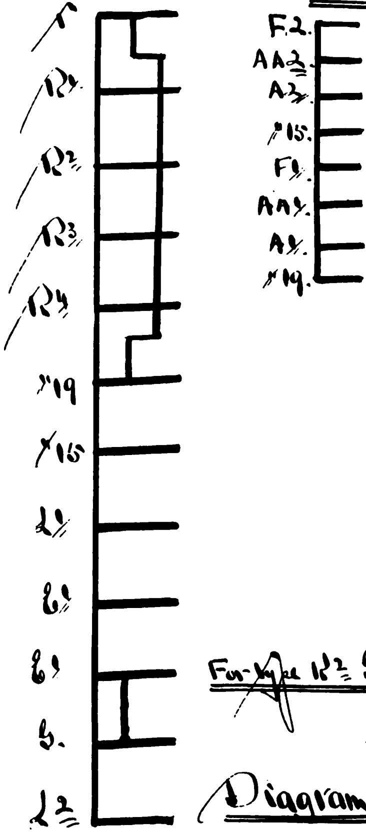


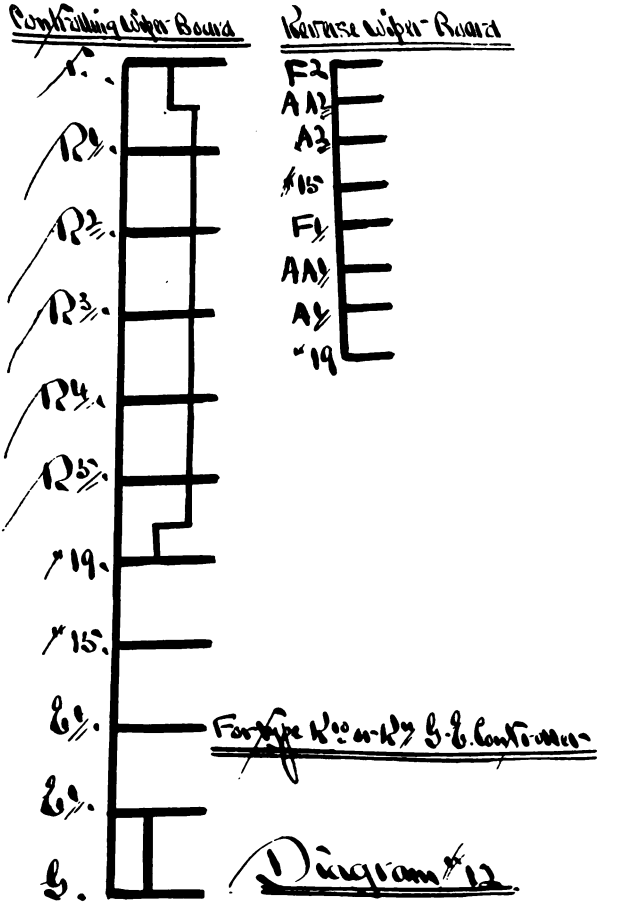
Diagram X 10 For Type
G.E. K. or K2 Controller.

Controlling Wiper Board — Reverse Wiper Board



For Type R2 G.E. Controller

Diagram No 11.


Centralling Wiper Board
Remote wiper Board
F2
AA2
A2
15
F1
AA1
A1
19
R1
R2
R3
R4
R5
19
15
G1
G2
G
Diagram 12

To operate number 2 motor without controller cylinder and without resistance, proceed as follows:

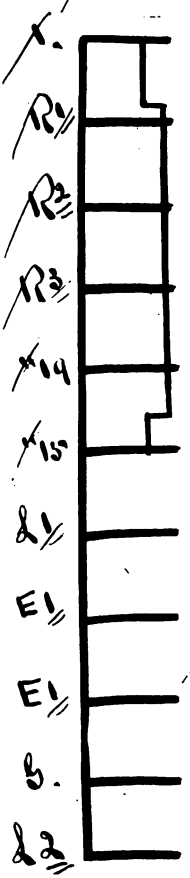
Connect the contact wiper marked T with contact wiper marked number 15, with wire. The above connection forms a circuit with number 2 motor's connection and motor can be operated in either direction with the reverse switch placed in connection, operating circuit by use of main motor switch. See Diagrams 13, 14 and 15.

To operate number 1 motor without controller cylinder and with resistance:

Connect the contact wiper marked T with contact wiper marked R-1, then connect contact wiper marked E-1 to contact wiper marked G, which is ground. This connection forms a complete circuit of number 1 motor's connections with entire exterior resistance in circuit and motor can be operated in either direction with reverse switch placed in connection, operating circuit by use of the main motor switch. See Diagrams 16, 17 and 18.

To operate number 2 motor without controller cylinder and with resistance, proceed as follows:

Controller Wiper-Board.



Reverse Wiper Board.

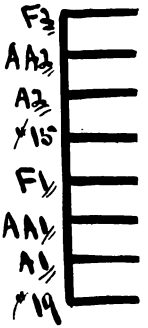


Diagram #13 For Type G.E. K or K'' Controller.

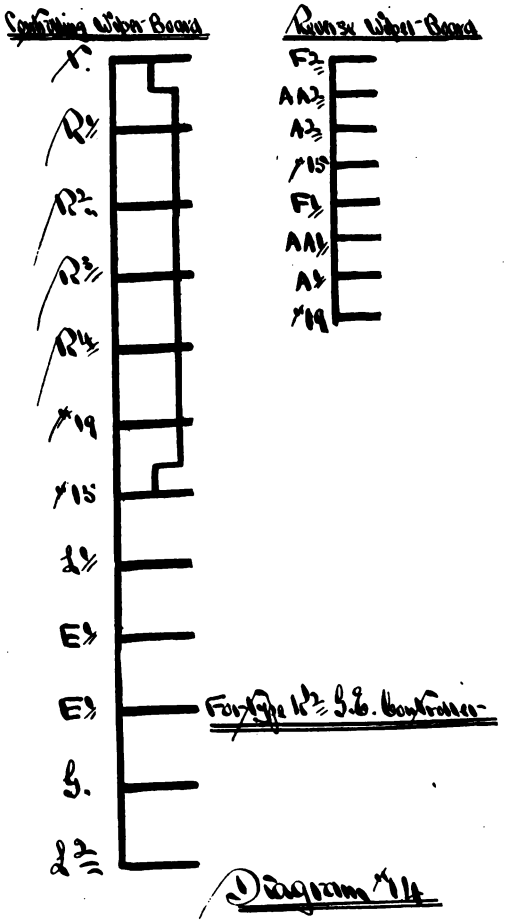
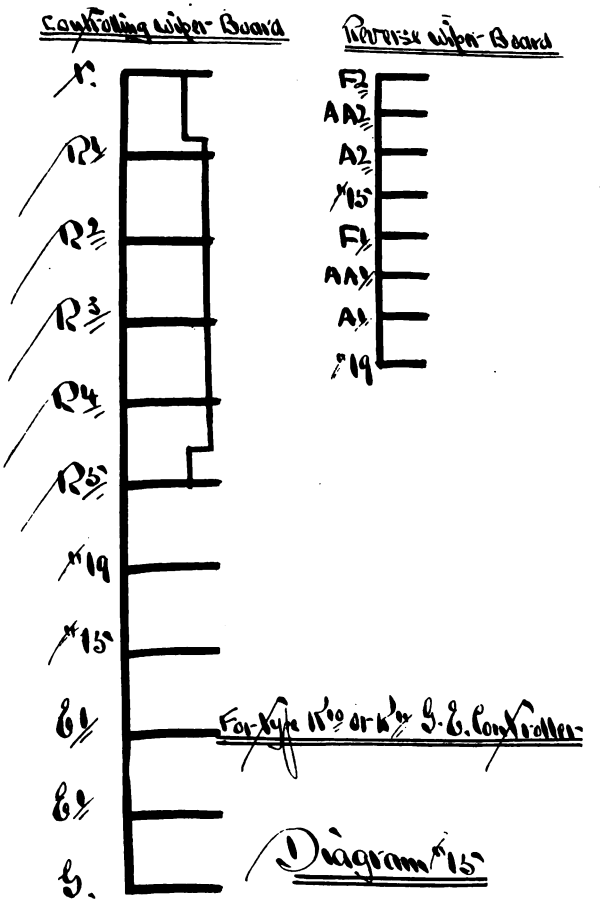
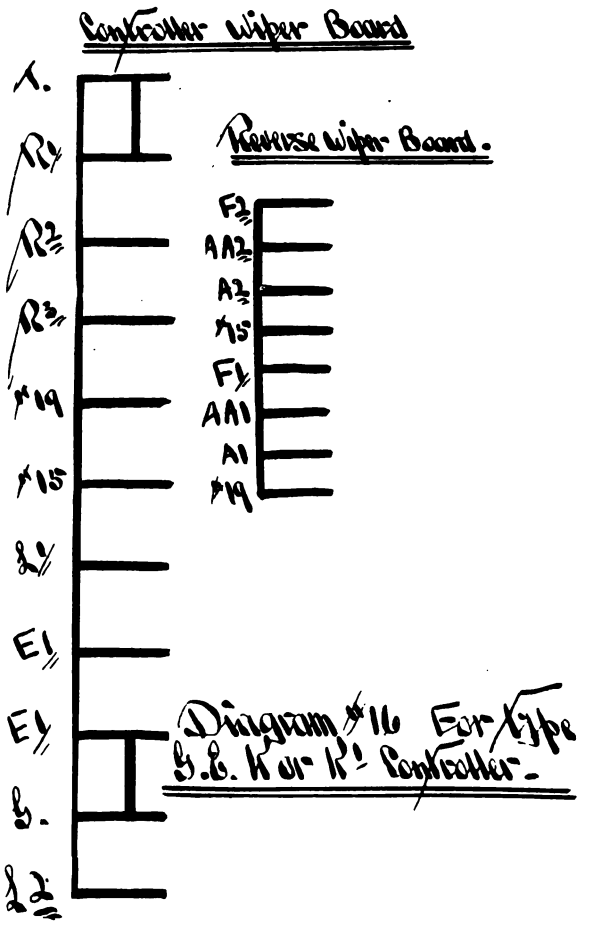
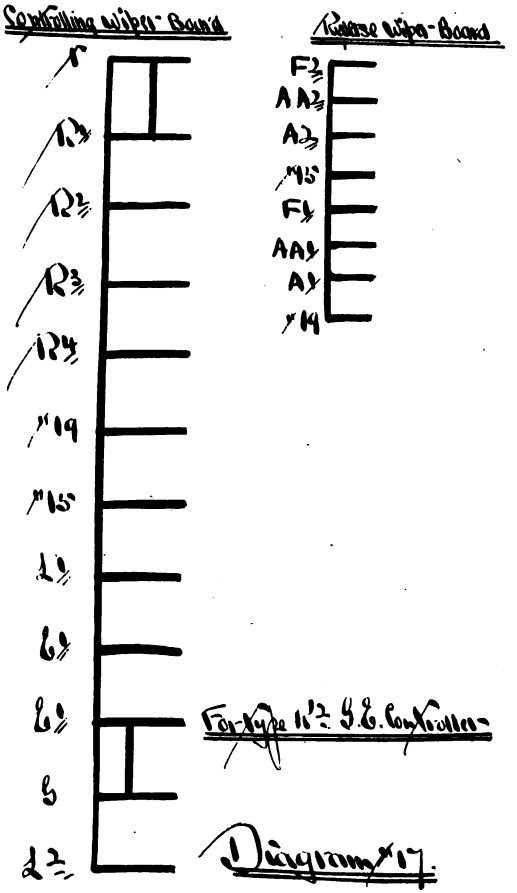
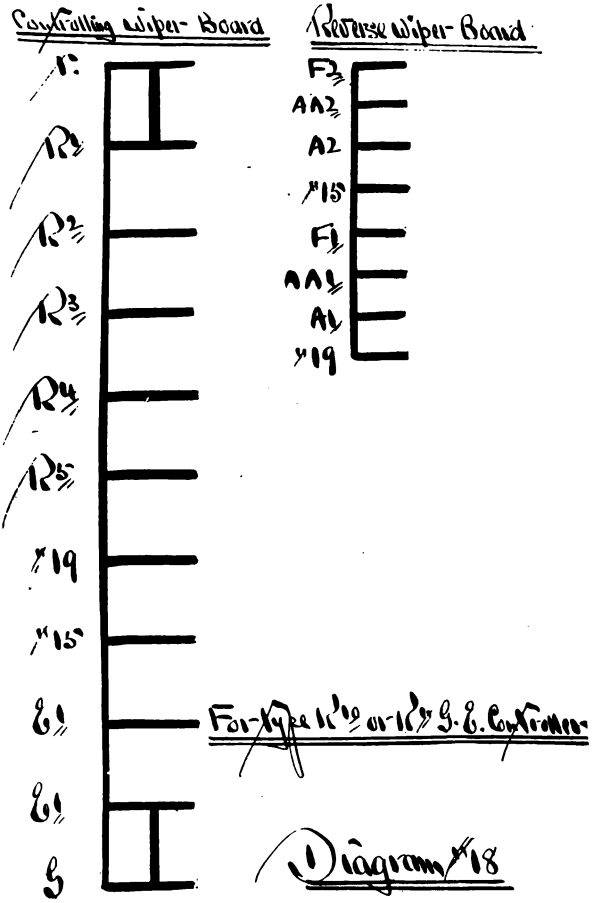


Diagramm 114


Controlling wiper-Board
R.
R1
R2
R3
R4
R5
*19
*15
61
61
5.
Reverse wiper-Board
F2
AA2
A2
*15
F1
AA1
A1
*19
For type 1500 or 1600 G.E. Controller.
Diagram *15


Controller Wiper Board
1.
R1
R2
R3
#19
#15
2
E1
E1
3.
2
Reverse Wiper Board.
F2
AA2
A2
#15
F1
AA1
A1
#19
Diagram #16 For Type
B.B. K or K1 Controller.


Controlling wiper-Board
Reverse wiper-Board
F2
AA2
A2
M5
F1
AA1
A1
M4
R1
R2
R3
R4
M9
M5
L1
L2
L1
L
L2
For type H2 S.E. Controller
Diagram 17.


Controlling wiper-Board
Reverse wiper-Board
R
R1
R2
R3
R4
R5
19
15
G1
G1
G
F3
AA2
A2
15
F1
AA1
A1
19
For Figs 11 to 16 see G.E. Controller
Diagram 18

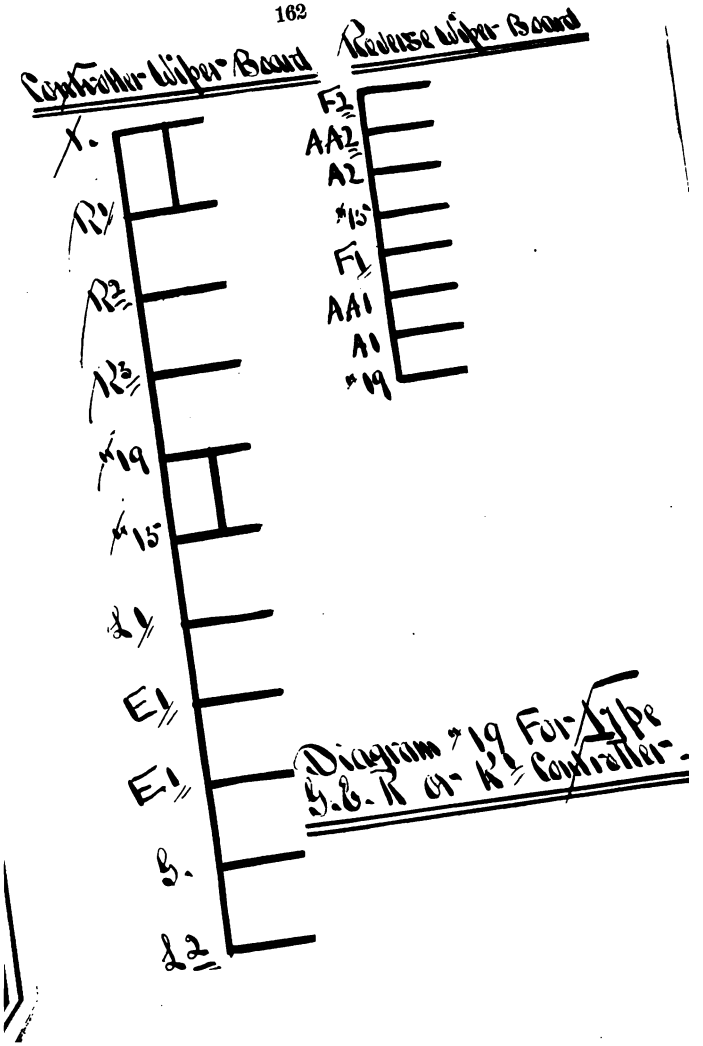
First throw up number 1 motor's cut-out switch, then connect contact wiper marked T with contact wiper marked R-1 with wire, then connect contact wiper marked number 19 to contact wiper marked number 15. This connection forms a complete circuit with number 2 motor's connections with entire exterior resistance in connection with same, and motor can be operated in either direction with the reverse switch placed in connection, operating circuit with main motor switch. See Diagrams 19, 20 and 21.

SUGGESTION.

The aforementioned, relative to the method of operating a motor with the current direct and full pressure of line applied at terminals of motor is not thoroughly a practical idea, but could be done in extreme cases of emergency, and is given for information only.

OPEN CIRCUITS.

An open circuit means that the circuit is either broken or parted at some point or other. When an open circuit occurs on trolley wire circuit of car between trolley stand


Conductor-Wiper-Board
Reverse Wiper-Board
X.
R½
R2½
R3½
*19
*15
L½
E1½
E1½
B.
L2½
F2½
AA2½
A2½
*15
F1½
AA1
A1
*19
Diagram *19 For Type
Y.B.K or K½ Controller.

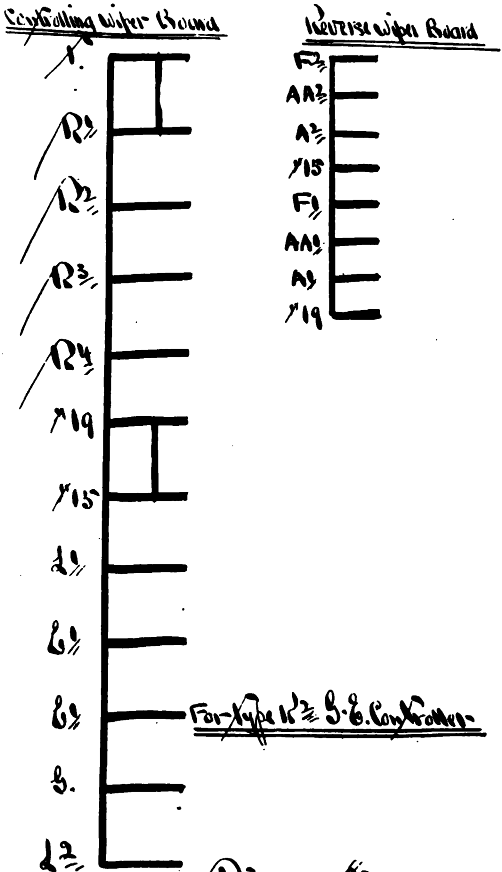
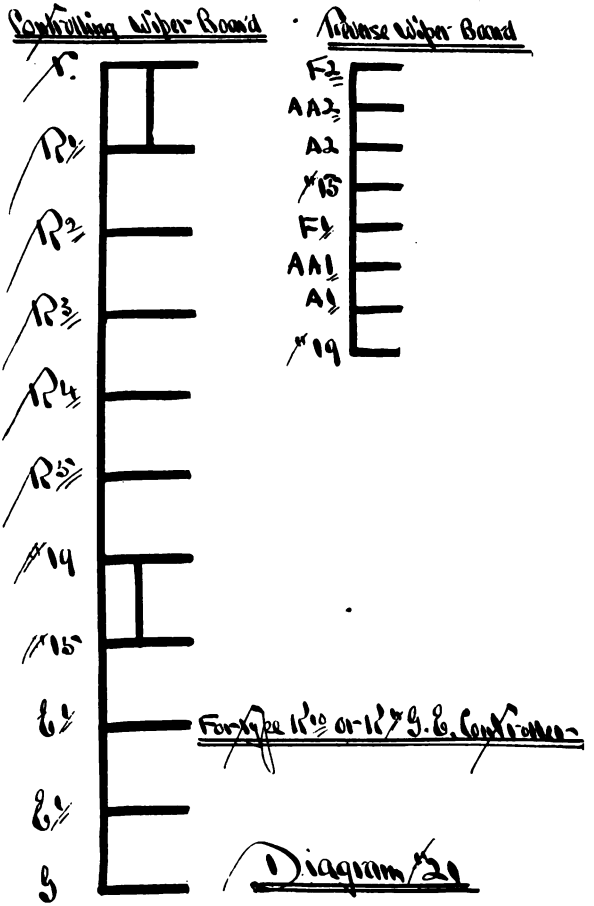

Controlling Wiper Board
Reverse Wiper Board
For Type K2 G.E. Controller

Diagram #20


Supplying Wiper Board
Intense Wiper Board
R
R½
R2½
R3½
R4½
R5½
14
15
6½
8½
9
F2½
AA2½
A2
15
F1½
AA1½
A1½
19
For Type 11½ or 12½ G.B. Equipment
Diagram 21

and contact wiper in controller, two distinct conditions arise—first, that motors cannot be operated in either direction on any position with controller; second, if the open circuit is located between the trolley stand and number 1 main motor switch, the lamp circuit cannot be operated; but if the open circuit is located between the negative side of number 1 main motor switch and the positive side of number 2 main motor switch the lamp circuit can be operated.

The cause of this is that the main circuit wires of lamp circuits are usually attached to the positive lead of number 1 main motor switch or circuit breaker.

When an open circuit occurs, either in the wire leading to the fuse box, or wire leading to and connecting with the lightning arrester, or wire leading to and connecting with wire in cable marked T, the car cannot be moved in either direction on any position with controller.

When the open circuit occurs with the R-1 wire, or in panels of resistance of this connection, the motors cannot be operated on the first position of the controller, but may on

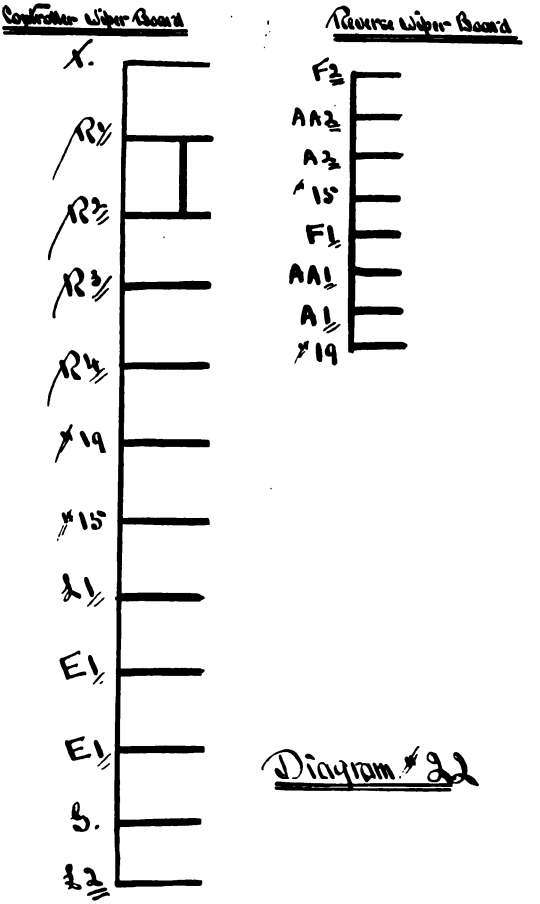

Controller Wiper Board
X.
R1
R2
R3
R4
#19
#15
A1
E1
E1
B.
A2
Reverse Wiper Board
F2
AA2
A2
#15
F1
AA1
A1
#19

Diagram #22

the second position. To overcome this defect, connect R-1 and R-2 contact wipers in controller together with wire. This will allow the motors to be operated on the first position, but the motors will acquire the same speed as they would on the second position, if there had been no open circuit at all. See Diagram number 22.

When an open circuit occurs on the R-2 wire, the motors can be operated on all series positions, but cannot be operated on the first parallel position of controller. When the open circuit is located in the panels of resistance, the motors cannot be operated until the third position is attained on the controller. Also, the motors cannot be operated on the first parallel position. To overcome this defect, connect the R-2 and the R-3 contact wipers in controller together with a piece of wire. This will allow the motors to be operated on all positions with the controller, the motors acquiring the same speed on the second position as that of the third. The object of forming this connection, is so that the motors may be operated on each and every

position with controller. For making this connection, see Diagram number 23.

When an open circuit occurs on the R-3 wire and the defect is located between the contact wiper in controller and tap on resistance jumper wire, the motors can be operated on all positions with the controller. When an open circuit occurs on jumper wire between the 1st rheostat and R-3 tap lead, the motors cannot be operated until the third position is attained; also, on the seventh as well, the sixth position being cut out.

To overcome the last-named defect, connect the R-2 and R-3 contact wipers in controller together with a piece of wire, the same as in Diagram number 23. When the open circuit occurs in the panels of resistance of the R 3 connection, the motors cannot be operated until the fourth position is attained; also, cannot be operated until the eighth position is attained as well on the controller. To overcome this defect, connect R-3 and R 4 contact wipers in controller together with a piece of wire; this will allow the motors to be operated on all positions with controller, the motors acquiring the

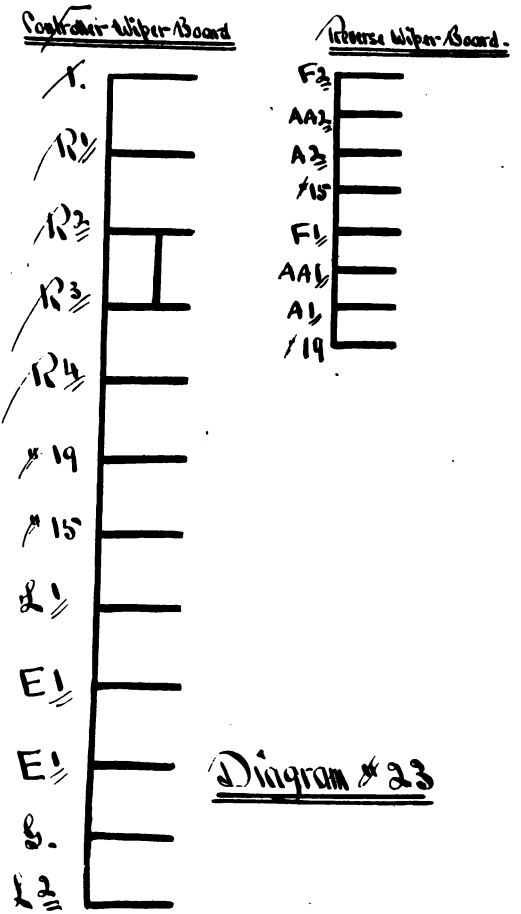

Contrary Wiper Board
V.
R1
R2
R3
R4
19
15
L1
E1
E1
B.
L2
Reverse Wiper Board.
F2
AA2
A2
15
F1
AA1
A1
19

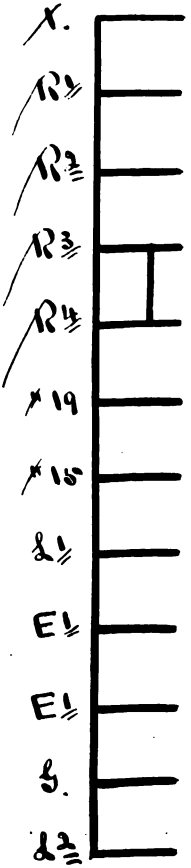
Diagram 23

same speed on the third position as on that of the fourth. This applies to the G. E. controllers types K-2, K-10 and K-11. To form this connection see Diagram number 24.

When an open circuit occurs on the R 4 wire of a type K-2 controller, the motors cannot be operated except on the fourth, fifth, eighth and ninth positions, respectively. To overcome this defect, connect R-3 and R-4 contact wipers in controller together with a piece of wire; this will allow the motors to be operated on all positions with controller, motors acquiring the same speed on the third position as on that of the fourth. This applies to the G. E. controllers, types K-2, K-10 and K-11. To form this connection see Diagram number 24.

When an open circuit occurs on the R-4 wire of a type K-10 or K-11 controller, the motors can be operated on all positions with controller; but if open circuit occurs in panels of resistance the motors can be operated only on the fifth and ninth positions respectively. To overcome this defect connect R-4 and R-5 wipers together in controller with a

Contrater Wiper Board



Reverse wiper Board.

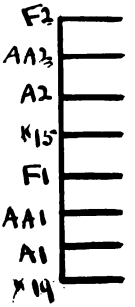


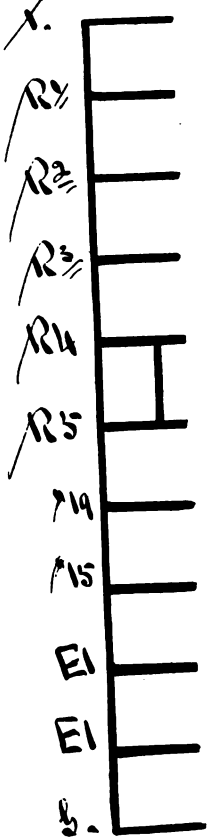
Diagram X 24

wire; this will allow the motor to be operated on all positions with the controller, the motors acquiring the some speed on the fourth position as that of the fifth. This applies to the G. E. controller type K-10 and K-11. To form this connection see Diagram number 25.

When an open circuit occurs on the R-5 wire of a type K-10 or K-11 controller the motors can be operated on the fifth and ninth positions only. To overcome this defect connect contact wipers R-4 and R-5 together as in Diagram number 25. This connection closes the circuit with rheostat or resistance and allows the motors to be operated on all positions with controller, the motors acquiring the same speed on the fourth position as that of the fifth.

When an open circuit occurs on the field lead of motor and are in connection with a G. E. type K, K-1 and K-2 controller, with shunt method in connection, the motors cannot be operated until the fourth position on a K or K-1 controller is attained, or until the fifth position is attained on the type K-2 controller. To locate the defective motor,

Centre wiper-Board



Reverse wiper Board

Diagram *25

first cut out the number 1 motor and try to operate the car on the first position with controller, but if circuit cannot be formed, cut in the number 1 motor and try by cutting out the number 2 motor. When an open circuit occurs on an armature lead or reverse switch connection the motors cannot be operated on any of the series positions, but motor in circuit can be operated on any of the parallel positions.

When an open circuit is located on number 1 motor's armature lead or reverse switch connection, the number 2 motor cannot be operated until the first parallel position of the controller is attained. When an open circuit is located on number 2 motor's armature lead or reverse switch connections, the number 1 motor cannot be operated until the arrow indicator of the controlling cylinder handle is midway between the series and parallel position.

DEFECTS IN MOTORS.

Under this heading a brief description of the various troubles and causes in street railway motors will be explained.

FIRST—GROUNDED ARMATURE.—A grounded armature is the result of one or more of the armature coils becoming in metallic connection with armature core or pole piece. This defect causes fuse to be blown in circuit, and shows up respectively with the series and parallel positions on the controller, namely, when the defect is located in number 1 motor's armature circuit the fuse will be blown on the series positions, and when located in number 2 motor's armature circuit the fuse will be blown on the parallel positions with controller, providing both motors are held in circuit by their respective cut-out switches.

SECOND—GROUNDED COMMUTATOR.—A grounded commutator is the result of a segment or segments of the same becoming in metallic connection with the frame which supports it. This defect causes fuse to be blown in circuit, the same as that of grounded armature coil. This defect is either caused by an accumulation of carbon dust, or grease from the outer edge of commutator and extending to shaft of arma-

ture which allows a short circuit to take place and causes fuse to be blown in circuit.

THIRD—GROUNDED FIELD.—A grounded field is the result of the coil of wire composing same to become in metallic connection with motor frame at some point or other. This defect causes fuse to be blown in circuit, providing that a majority of the field circuit is cut out by this ground and shows up respectively with the series and parallel positions of controller, namely, when the defect is located in number 1 motor's field circuit the fuse will be blown on the series positions, and when located in number 2 motor's field circuit the fuse will be blown on the parallel positions of controller providing both motors are held in eircuit by their respective cut-out switches.

FOURTH—WEAK FIELD.—A weak field is caused by the insulation becoming carbonized, which allows a partial short circuit to be effected upon its own circuit. This defect causes fuse to be blown when using the last running position of a controlling device and can be located in either number 1 or number 2

motor. It is also noticeable by the retarded movement of car when current is first applied and on first position of controller, but afterwards by a sudden speed being effected by the motors.

FIFTH—GROUNDED BRUSH HOLDER.—A grounded brush holder is the result of the metallic frame composing the same, becoming in connection with motor frames either by some metallic connection or by carbonization of brush-holder yoke. This defect causes fuse to be blown in circuit as follows: When the metallic frame is in metallic connection with motor frame and located in number 1 motor the car cannot be operated in either direction, causing fuse to be blown on series positions with controller. When located in number 2 motor the car can be moved on the series positions, the fuse being blown on the parallel positions of the controller.

When the grounded brush holder is caused by carbonization the fuse will be blown when using the last position of controller and can be located in either number 1 or number 2 motor. To determine which motor carries this defect, first cut out number 1 motor,

testing the circuit of number 2 motor on series position with controller. If no fuse is blown with this test, the ground will be located in number 1 motor as cut out, but if fuse is blown, cut in the number 1 motor and cut out number 2, which will allow a test to be made with number 1 motor's circuit.

When the wires F-1 and F-2 at the shunt connection becomes short circuited with each other, and both motor's are cut in with their respective switches, a car cannot be moved in either direction, causing fuse to be blown on series position with controller, but can be moved in either direction when either number 1 or number 2 motor is cut out.

MAIN MOTOR SWITCH.

A main motor switch is an electrical device placed in circuit of trolley wire in car wiring for the purpose of opening or closing that circuit at both ends of car. They also have several other names given them, namely, overhead switch, canopy switch, and are sometimes called auxiliary switches. The switches are so constructed that a blow-

out magnet coil is placed in circuit with switch lever for the purpose of breaking an arc when opening the circuit. The magnet coils are inserted in interior of switch.

FUSE BOXES.

A fuse box is an electrical device placed in the trolley circuit of car wiring, for the purpose of opening a circuit (by the blowing of fuse) when an overload of current is applied, thereby protecting the electrical equipment of car. This device is usually constructed in box form, in which are inserted two binding posts, representing positive and negative poles of the device, to which are attached two wires,—one the trolley wire, which is attached to the positive binding post of the device, and the other wire attached to the negative binding post, is the wire leading to and connects with through lightning arrester to trolley contact wiper in controller. The fuse box is usually equipped with a blow-out magnet coil, which is in connection with the positive binding post of device, the office of which is to extinguish the arc when fuse is blown.

LIGHTNING ARRESTER.

The lightning arrester is a device placed on the trolley wire circuit of car wiring, between the fuse box and the controller connections, for the purpose of grounding an excessive charge which might occur on the line, resulting from lightning. This device is usually placed in the trolley circuit, between the fuse box and trolley contact wiper in controller or rheostat spindle in T. H. system.

THE CAR MAGNETIC CIRCUIT BREAKER.

A magnetic circuit breaker is an electrical device which works automatically on its own circuit with a certain amount of current. It is constructed for the specific purpose of opening the circuit when an overload of current occurs, thereby protecting the electrical equipment of a car. When a car is equipped with this device it obviates the use of a fuse box in that circuit. This device is only in circuit with controller on that individual end of the car, so that when tending to operate car at the opposite end the circuit breaker last used should be tripped to open

the circuit. The construction of this device usually consists of two binding posts, to which are attached the positive and negative wires, and in the circuit is placed a blow out magnet coil, the function of which is to attract what is known as the armature, and releasing the trip which secures the contact lever. The cause of this armature being attracted is the result of an overload of current, which is excessive to that of the adjustment on the graduating scale and increases the magnetic field so that the armature is attracted by the pole piece of coil.

LAMP CIRCUIT.

The lamp circuit used in cars is what is known as a series circuit, with usually 5 lamps in the same, and the number of circuits in a car is one or more, and usually not to exceed three. One of these circuits is in connection with the headlight of the car, of which there are 6 lamps, but only 5 being placed in service by two-way lamp switch. The entire number of these circuits are controlled with one main lamp switch, usually for cutting in and cutting out circuit.

SERIES OF QUESTIONS AND ANSWERS RELATIVE TO THE OPERATION OF ELECTRIC CARS.

Q. What is the office of a fuse?

A. To prevent an overload of current at the motor terminals.

Q. How does a fuse prevent an overload of current at motor terminals?

A. By fusing or melting when an overload of current occurs in that circuit.

Q. What is meant by an overload of current?

A. An overload of current means that amount of current which exceeds the carrying capacity of the fuse in circuit.

Q. What produces an overload of current?

A. An overload of current is produced by grounds or short circuits in wiring of motors, which causes a small amount of resistance and allows the load to rise, as per example:

A line has 500 volts pressure, a motor becomes short circuited with which ground causes little resistance. The amount of resistance being two ohms, the amount of current passing this circuit would be equal to

500 volts, divided by two ohms, which allows 250 amperes of current to pass. This would be an overload for a 150-ampere fuse, being exactly 100 amperes above the carrying capacity of the fuse.

Q. Are there any other causes for producing an overload?

A. Yes, an overload is also caused by improper use of controller, such as feeding too fast, or by reversing, or is caused by lightning striking the line, which allows a heavy charge upon the line.

Q. Why is the fuse made to be the weakest part of the circuit?

A. So as to rupture the circuit at that point.

Q. Why is it necessary to rupture the circuit at that point?

A. So as to protect the equipment.

Q. At what part of the circuit is the fuse usually placed?

A. Between the second main motor switch and the lightning arrester or controller.

Q. Of what material is a fuse usually composed?

A. A fuse is usually composed of lead,

with a certain amount of tin in its composition.

Q. How is the carrying capacity of a fuse designated?

A. By having the number of amperes stamped on one of the copper terminals of the fuse.

Q. What precaution should be used in inserting a fuse?

A. When inserting a fuse the composition part should be so bent as to leave an air space between the face of the fuse box and fuse, and terminals of fuse should be thoroughly secured with thumb screws of binding posts.

Q. Why is it necessary to have an air space between the face of the fuse box and fuse?

A. To allow a current of air to pass around the fuse, thereby overcoming to a certain extent the rise in temperature caused by an overload of current.

Q. Why is it injurious to the equipment to use any heavier than the regular fuse?

A. The office of a fuse is analogous to that of a safety valve on a steam boiler. If the safe carrying capacity of the boiler is 150

pounds to the square inch and the safety valve is set to blow off at 100 pounds, the boiler is safe; but if the valve is set at 200 pounds there is danger of the boiler bursting. If the circuit of the motor requires a 100 ampere fuse and a 200 ampere fuse should be placed in that circuit it would be liable to result in damage to motors or controllers.

Q. Why is it injurious to run on resistance points?

A. On account of heating resistance coils.

Q. What causes the coils to heat?

A. By current being retarded by the resistance of coils.

Q. Why is resistance used in a motor circuit?

A. Resistance is placed in circuit, with a motor for the purpose of overcoming a rush of current to motor terminals, which would cause a too sudden movement of armatures.

Q. How is the resistance sometimes spoken of relative to the motor circuit?

A. The resistance, in connection with a motor circuit, is sometimes termed exterior resistance.

Q. What are resistance coils also called?

A. Rheostat or diverter coils.

Q. What are resistance coils composed of?

A. For street railway motors the resistance is generally composed of long strips of iron ribbon. Several years ago resistance coils were composed of German silver wire, but for commercial reasons this has been discarded for either wrought or cast iron.

Q. How are the resistance coils made up?

A. Resistance coils are made up in two forms, one of which is known as the panel form, and are placed in layers, with asbestos between each layer; the other is cylindrical in shape, with asbestos or mica insulation, separating the layers of the coil.

Q. Why is asbestos or mica placed between each layer?

A. To prevent the coils from being short circuited and to secure the full resistance of the coil. Both of these materials are insulators and are capable of standing a high temperature without deterioration.

Q. What is meant by short-circuited?

A. A short circuit means that the current instead of going through its regular course, is carried to ground through a shorter

pathway on account of the lessening of resistance.

Q. What are the safe running points on a G. E. K. or K-1 controller?

A. The safe running points are 3, 4, 6 and 7.

Q. What are the resistance points on a G. E. K. or K-1 controller?

A. The resistance points are 1, 2 and 5.

Q. What are the safe running points on a G. E. K-2 controller?

A. The safe running points are 4, 5, 8 and 9.

Q. What are the resistance points?

A. The resistance points are 1, 2, 3, 6 and 7.

Q. What are the safe running points on a G. E. K-10, K-11, or K-12 controller.

A. The safe running points are 5 and 9.

Q. What are the resistance points?

A. The resistance points are 1, 2, 3, 4, 6, 7 and 8.

Q. How are the different points designated?

A. The safe running points are designated by the long bars on the dial plates, and the

resistance points are designated by the short bars on the dial plate. All these bars are raised above the surface of the plates.

Q. What are the safe running points on a Westinghouse 28-A controller?

A. The safe running points are 4 and 7, marked, respectively, ½ speed and full speed.

Q. What are the resistanee points?

A. The resistance points are 1, 2, 3, 5 and 6.

Q. Where is number 1 motor located relative to end of car?

A. Number 1 motor is always termed as being the motor nearest the fuse-box.

Q. Where is number 2 motor located?

A. Motor 2 is always termed as being the motor farthest away from the fuse-box.

Q. How is number 1 motor cut out in a G. E. controller?

A. By throwing up the left-hand switch in controller.

Q. How is number 2 motor cut out in a G. E. controller?

A. By throwing up the right-hand switch.

Q. How is number 1 motor cut out in a Westinghouse 28-A controller?

A. By placing the handle of the number 1 cut-out plug in a vertical position in both controllers. The number 1 cut-out plug is the bottom one.

Q. How is number 2 motor cut out in a Westinghouse 28-A controller?

A. By placing the handle of the number 2 cut-out plug in a vertical position in the controller that is being operated at the time. The number 2 cut-out plug is the top one.

Q. What precautions are necessary before cutting out a motor?

A. Always throw off the overhead switch or circuit breaker. This should also be done when inserting a fuse.

Q. Why is it injurious to the motors to run the car with the power on and brakes partly set?

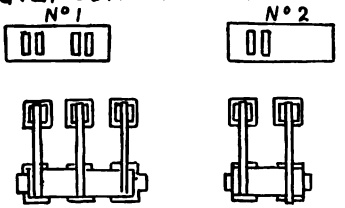
A. Because it heats the armatures and fields and destroys the insulation.

Q. How does heating destroy the armature and field-coil insulation?

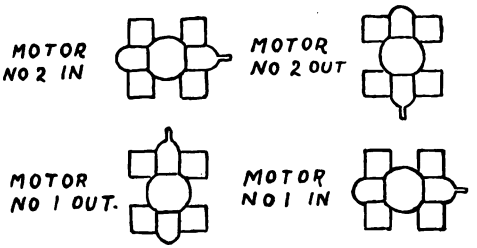
A. By carbonization.

Q. What defect is liable to be caused by carbonized insulation of armature or field coils?

MOTOR CUT OUTS
G.E. CONTROLLERS.



MOTOR CUT OUTS
W.H. CONTROLLERS.



A. A short circuit, or ground, caused by the layers of the coils of wire coming in metallic connection with each other.

Q. What is the result usually of running the car through water at an excessive rate of speed with the power on?

A. It is liable to produce short circuits in the motor with armature, field coils or brush holder yokes, also a possibility of producing short circuits in resistance coils.

Q. What is meant by controller interlocking device?

A. A controller interlocking device is a mechanical arrangement whereby the controlling cylinder is prevented from being op erated when the reverse handle is in the centre; also reverse cylinder is prevented from being thrown in either direction when controlling cylinder is placed in circuit or connection.

Q. What systems are equipped with this device?

A. General Electric and Westinghouse principally.

Q. How would you operate a car with a

grounded controlling cylinder equipped with a G. E. controller?

A. Usually the car is operated from the rear controller or by wiring from trolley wiper to wiper marked number 19 and wiring wiper number 15 to wiper marked E-1. This connection places both motors in series without resistance, and motors can be operated in either direction by setting of reverse switch and applying power to controller and thence to motors by means of the overhead switch, throwing it on to start and to the off position to stop.

Q. How would you operate a car with entire resistance in circuit, motors in series and controller cylinder grounded and car equipped with a G. E. controller?

A. Connect a wire from trolley wiper to R-1 wiper, and connect a wire from wiper marked number 15 to the E-1 wiper. Controlling direction of the car by means of reverse switch, and applying the power with overhead switch.

Q. Which wiper is the trolley wiper in a G. E. controller?

A. The one at the top of the wiper board of controller.

Q. Which wiper is the trolley wiper in a Westinghouse 28-A controller?

A. The one at the top of the controller.

Q. Which wiper is the number 19 in a G. E. controller?

A. On a G. E. type K, or K-1 controller, the number 19 wiper is the 5th wiper down from the top. On a type K-2 G. E. controller, the number 19 wiper is the 6th one down from the top of the controller. On a G. E. type K-10, K-11 or K-12, the number 19 wiper is the 7th wiper down from the top of the controller.

Q. Which is the number 15 wiper in a G. E. controller?

A. On a G. E. type K or K-1 controller, the number 15 wiper is the 6th wiper down from the top of the controller.

On the type K-2, the number 15 is the 7th wiper down from the top of the controller.

On the type K-10, K-11 or K-12, the number 15 is the 8th wiper down from the top of the controller.

Q. Which wiper is the E-1 in a G. E. controller?

A. On a G. E. type K, or K-1, the wipers marked E-1 are the 8th and 9th wipers down from the top of the controller.

On a K-2, K-10, K-11 or K-12, the wipers marked E-1 are the 9th and 10th down from the top of the controller.

Q. Which is the R-1 wiper in a G. E. controller?

A. The R-1 wiper is the 2d wiper down from top of controller. This applies to all types of G. E. controllers. The R-2, R-3, R-4 and R-5 wipers, follow in numerical order.

Q. In making these connections are there any precautions necessary?

A. As a safeguard it is advisable to throw the overhead switch to the off position, and be careful that the wires do not touch the controller casing or cover. Also insulated wire should be used, excepting at both ends, from which the insulation must be removed to secure proper contact.

Q. How would you operate a car with a grounded reverse cylinder G. E. controller?

A. By throwing reverse cylinder entirely out of connection and then wiring the reverse contact wipers in pairs for a forward movement of the car and cross connect the reverse contact wipers for a backward movement of the car.

Q. What is meant by connecting the reverse contact wipers in pairs?

A. To connect the reverse contact wipers in pairs means, that the bottom contact wiper is to be taken as number 1, and that to be connected to the second contact wiper, up on reverse switch, which is number 2, leaving the remaining six wipers to be connected in pairs in a similar manner; or, to make it more plain, connect the third and fourth wiper together, which along with number 1 and 2 wipers constitutes number 1 motor's connections, then connect together the fifth and sixth wipers and also the seventh and eighth, which constitutes number 2 motor's connection.

Q. In which direction will the car run when the connections are made as previously explained?

A. In a forward or go-ahead direction from

the end of car upon which the connections are made.

Q. How would you obtain a backward motion of the car?

A. By a cross connection of reverse contact wipers.

Q. How is the cross connection made?

A. By connecting the bottom reverse wiper to the third wiper and connect together the second and fourth, which constitutes number 1 motor's connections; also connect fifth and seventh wipers together and then the sixth and eighth, which constitutes number 2 motor's connections.

Q. What would be the result if a blow-out magnet coil in a controller became grounded?

A. A grounded blow-out magnet coil in either controller will cause fuse to be blown in circuit when both overhead switches or circuit breakers are thrown on to close the circuit and controller being at off or normal position.

Q. How would you run a car with a grounded blow-out magnet coil?

A. By disconnecting the positive and negative wires of same and connect together.

This leaves the blow-out magnet coil entirely out of the circuit.

Q. What is a blow-out magnet coil?

A. A blow-out magnet coil is composed of a certain number of turns of insulated copper wire or ribbon wound on a core.

Q. What is the office of a blow-out magnet coil in a controller?

A. To excite what is known as the pole piece for the purpose of producing magnetic lines of force, so as to break the arc when throwing the controller to the off position.

Q. Why is it necessary to break the arc?

A. To protect the controller from grounds or short circuits, which might be caused by an arc held in the controller.

Q. What other precautions are taken to minimize the arc at contact wiper point?

A. Controllers are also equipped with what is known as arc deflectors or barriers, which are placed between each contact wiper to prevent an arc being blown from one contact wiper to another, and on G. E. controllers are attached to the swinging pole piece of the controller.

Q. Why is it injurious to apply the power too abruptly?

A. When the power is applied too abruptly it allows a rush of current to motor terminals and is liable to produce short circuits in motors, either on brush-holder yoke or armature circuits. There is also a possibility, with the aforesaid defects, of a current backing up in the controller and causing short circuits or grounds. In regards to mechanical defects liable to result from a too rapid application of the power there is a possibility of stripping the gears and pinions.

Q. What is meant by an emergency stop with controller?

A. By an emergency stop is meant to make a stop with the controller irrespective of the power in the line or brakes on car.

Q. How is the stop made?

A. By throwing to off position the overhead switch then throwing the reverse handle in the opposite direction from which the car is proceeding and then throwing the controller cylinder handle to the last parallel position, allowing it to remain there until the effect is produced.

Q. How is this effect produced?

A. By a generation of current produced by the motors when held in opposite polarity, which tends to make the stronger motor a generator and the weaker one to be driven as a motor in the opposite direction.

Q. What is meant by the stronger motor when both motors are supposed to be of an equal horse power, being also of the same type?

A. The stronger motor relates to the strength of the magnetic field.

Q. Under what conditions should this emergency stop be made?

A. This stop is to be resorted to only when there is a failure of power on line and braking apparatus out of order, so as avert an accident.

Q. What would be the result if the reverse switches were set for a forward direction with both controllers and the power was applied from one end?

A. The car could not be moved in a forward direction with either controller, and fuse would be blown in circuit on the series positions with either controller.

Q. Suppose that the reverse switch on number 1 controller were set for forward motion and on number 2 controller set for a backward motion, what would be the result?

A. The car could be moved in a forward direction with number 1 controller on all positions without blowing fuse.

Q. What is meant by the series positions?

A. By a series position is meant that two motors are placed in circuit so that current flows through number 1 motor, but does not complete its circuit until passing through number 2 motor.

Q. What is meant by a parallel or multiple position?

A. By a parallel or multiple position is meant that each motor is independent upon its own circuit.

Q. What is liable to result by throwing the reverse switch with the power on as can be done with some makes of controllers?

A. This produces a short circuit in controller, causing fuse to be ruptured in circuit, also might cause short circuit in armature coils.

Q. What is the usual voltage on line in street railway work?

A. Five hundred volts.

Q. What is a volt?

A. A volt is an electrical unit of pressure, and is the amount of pressure required to press one ampere of current through one ohm of resistance.

Q. What is an ampere?

A. It is an electrical unit of current.

Q. What is an ohm?

A. An ohm is the electrical unit of resistance.

Q. What is meant by the positive side of a circuit?

A. The positive side of a circuit is always termed as the side through which the current flows into a circuit. This is sometimes termed the plus side of a circuit.

Q. What is meant by the negative side of the circuit?

A. The negative side of the circuit means the return side of the circuit—the side which the current leaves at. This is sometimes termed the minus side of a circuit.

Q. What are the pole pieces of a motor?

A. The pole pieces of a motor are the iron magnets inside of the motor shell.

Q. Are these temporary or permanent magnets?

A. They are temporary magnets.

Q. Why are they called temporary magnets?

A. Because they become magnets only when excited by the field coils which surround them.

Q. When do they cease to act as magnets?

A. When the power is shut off.

Q. How many pole pieces are there in each motor?

A. Usually two or four.

Q. When composed of two, are they known by any technical terms to designate one from the other?

A. Yes; one a north pole and the other a south pole.

Q. When composed of four, how are they designated?

A. Two are called north poles, and the remaining two are south poles.

Q. When a motor has four pole pieces, why are there two north and two south poles?

NO. 8,760. G. E. 57—50 H. P. MOTOR—OPEN.

NO. 10,401. G. E. 67—38 H. P. MOTOR—OPEN.

A. So that the magnetic field may be evenly balanced in polarity to allow the attraction and repulsion of armature.

Q. What has the attraction and repulsion of armature to do with the movement of a car?

A. It causes the armature to revolve, which is in a geared connection with the truck axle, thereby securing propulsion of car.

Q. What are the different gear ratios of the several types of street railway motors?

A. The gear ratios range from 3 to 5 to 1 approximately.

Q. What is meant by gear ratio?

A. Gear ratio refers to size of pinion and gear.

Q, Give a more definite explanation?

A. A pinion has 17 teeth, or cogs, which meshes with a driving gear having 67 teeth or cogs. This gear ratio would be termed 4 to 1 approximately. By 4 to 1 is meant that the armature would revolve 4 times to 1 revolution of the car wheels.

Q. How are the gears and pinions made secure to truck axle or armature shaft?

A. Gears are made secure by means of a key which is inserted into a keyway cut into the truck axle and which protrudes above the surface of axle and fits into a keyway cut into the hub of gear. The gear is then fastened by means of bolts. Pinions are made fast to armature shaft by means of a key.

Some pinions are placed on armature shafts by means of expansion and become tightened or secure by contraction, while others are secured on the armature shaft by means of a key and nut on end of armature shaft.

Q. How is the expansion of a pinion caused?

A. By heating.

Q. How is contraction produced?

A. By cooling.

Q. Why are circuit breakers placed in the overhead trolley wire at intervals along the line?

A. The chief object of a circuit breaker in the overhead line is for the purpose of placing the line in sections, so that in case of a defect on one section the other sections would not be affected.

Q. Is it injurious to run over line circuit breakers with the power on?

A. It is.

Q. What is an electric track switch?

A. It is an electrical device used for opening or closing a switch for certain directions.

Q. What is its construction?

A. An electric track switch consists of what is known as an electro-magnet, and the armature has what is known as an inverted pendulum attached, the point of which is conical in shape, terminating with full apex, and when switch is operated the conical part of this pendulum seats itself into a recess in a slide bar, which is in connection with switch tongue point. This device is placed below the street surface between the two rails of track.

Q. What is its connection, and how operated?

A. The wire leading to electro-magnet coil is attached at one end to what is known as the insulated track or rails, and the other end is connected to the positive binding post of the electro-magnet coil. A wire is also attached from negative side of coil to the

return. wire of the track. This is a complete connection.

It is operated by the return circuit of motor of the car, and truck or trucks must stand in full on insulated track to operate magnet. When switch is set for the proper direction of the car, the trucks are allowed to pass over the insulated section of track, so as to form a connection with main return wire. When the last-named condition exists, it must be understood that the power must be shut off while passing over insulated section, otherwise the switch would be thrown.

Q. Is it dangerous to operate a car, at an excessive rate of speed over facing point switches?

A. It is.

Q. In what way is it dangerous?

A. It is dangerous on account of the possibility of the switch-tongue being thrown by the forward wheel of truck and thereby derailing the car.

Q. Are there any dangers attached to the backing of a car without first turning the trolley pole?

A. Yes. The danger of the trolley wheel becoming caught in the overhead line and becoming entangled which might possibly pull down the line, or possibly the trolley pole might become bent. Also the danger of an accident by car coming in contact with a person who might be crossing the street at the time.

Q. Is it dangerous for cars to pass one another on a curve?

A. It is, owing to the possibility of car on the inner rail becoming derailed and resulting in a collision with car on the outer curve.

Q. Should a car pass a standing car on the opposite track?

A. No. A full stop should always be made to allow any passengers that may have alighted from the standing car to cross the opposite track with safety.

Q. When placing a car in car house, at the end of the day's work, what should be done before leaving it?

A. See that the controllers are thrown to off stop and that the reverse switches are set at the centre, also that both overhead

switches are thrown to off stop and trolley wheel removed from the trolley wire.

Q. Should a motorman allow an unauthorized person to operate his car?

A. No. None but authorized persons should be allowed to operate a motor car.

Q. How would you be governed if the power was off of the line, relative to the operation of your car?

A. See that the controller is thrown to off stop and turn on lamp circuit, so as to ascertain when the power is on the line again.

Q. What should be done when power is on the line again after having been off relative to the movement of the car?

A. All cars should not be started at once, as this would place a heavy load on the line and cause the circuit to be opened again, possibly by fuse being blown or circuit breaker being thrown out at the station. Some railroad companies either have the series of even numbered cars start first or the series of odd numbers starting first. For example:

Cars numbered 200, 202 and 204 would be even numbers, and cars numbered 201, 203 and 205 would be odd numbers.

on the reverse spindle, which allows of a possibility, when reversing, to throw the reverse switch out of circuit, which would be detrimental in avoiding an accident, as motors could not be operated under this prevailing condition. When using the type K-10 or K-11 reverse handle on a K, K-1 or K-2 controller, the reverse could not be thrown owing to improper fit of handle.

Q. When using a type K-2 reverse handle on a K-10 or K-11 controller, why is it necessary to place it upside down on reverse cylinder spindle?

A. Owing to the stop block projection on the reverse handle being too short to fit into the groove of the reverse stop-block bracket.

Q. Why are cars equipped with M. M. switch, or circuit breakers, on each end of the car?

A. The M. M. switch, or circuit breaker, is placed on each end of the car for convenience to motorman to open the circuit when necessary.

Q. What is the proper way to operate a car going down a grade?

Q. If upon throwing the power handle to the first position and car does not move, but upon throwing it off a flash in the controller is observed, what does it signify?

A. It signifies that a ground or short circuit exists somewhere in motor circuit or car wiring, and usually the trouble is located in number 1 motor, or a possibility of it being located in the rheostatic circuit.

Q. What precaution should be taken by motormen in getting controller handles and reverse handles for the several types of G. E. controllers?

A. Great care should be exercised in securing the controlling and reverse handles for the several types of G. E. controllers, as the controller handles and reverse handles for the type K or K-1 controllers or K-2 should not be used on a type K-10 or K-11 controller, as the stop block on controller handle does not allow the last safe running position on controller to be placed in full contact and leaves a tendency to form an arc with contact wipers. When using a type K-2 reverse handle on a type K-10 or K-11 controller, the handle has to be adjusted upside down

quickly when the rails are in a glazed condition or greasy?

A. No. The motors should be built up slowly so as to prevent the wheels from slipping as far as possible.

Q. Should a car be operated with a hot journal bearing?

A. No, only to operate the car to the nearest repair station.

Q. What could be done if sleet and ice was formed on the trolley wire, which prevented a contact with the trolley wheel to the trolley wire?

A. The trolley wheel should be removed, allowing the fork to act as a scraper, great precaution being used not to back up the car without first turning the pole.

Q. What should be done when an arc is maintained after a fuse is blown?

A. Be sure and throw off main motor switch at once or else have the trolley wheel removed from the trolley wire.

Q. What are some of the causes of sprung axles?

A. A few of the causes are as follows:

Cars becoming derailed through careless-

ness of motormen or from defective tracks, by wheel dropping into recesses of worn castings.

Q. What is the proper course to pursue in case of a badly sprung axle?

A. Allow wheel to turn to the position where it best fits the gauge of the track, then lash it securely to the side of the truck, so as to prevent wheel from turning; also to have motor cut out on this particular pair of wheels so that the car may be operated, allowing this set of wheels to slide to car house.

Q. How can you tell when a car has a sprung axle?

A. By the see-saw or lateral movement of the car while in motion.

Q. What are some of the causes of flat wheels?

A. By too sudden an application of the brakes, causing the wheels to skid; also from soft spots in the chill of wheels.

Q. What are some of the causes of broken or chipped flanges on car wheels?

A. By allowing wheels to strike curves too abruptly, by wheel running off the rail and

being moved over paving stones, or from small stones or other foreign material that might be on the rail or track.

Q. How could a motor be raised with its own power when dropped?

A. By cutting out the suspended motor, and if the dropped motor was on the rear end of the car in that direction, the reverse switch should be thrown ahead for the forward direction of car; but if located on the front end of car in that direction, the reverse switch should be thrown for a backward motion of car. In either of these cases, only the first position on the controller should be used in raising a motor.

Q. Why is a fuse liable to melt out if not properly secured with a full contact surface at terminal?

A. On account of its small area of contact surface, which would allow a high resistance, which consequently produces a high temperature, causing the fuse to melt.

Q. What fuse are the most sensitive, covered or uncovered?

A. Covered fuse.

Q. Why are covered fuse used instead of uncovered, at the present time?

A. So that when fuse becomes ruptured, the covering prevents an exposure of the arc.

Q. When a car equipped with two motors cannot be operated on the series positions, but may on the parallel positions, what would be the cause?

A. The cause for this is what is known as an open circuit, and may be located either on the field or armature leads of motor or any of its contact connections representing the leads of those motors.

NOTE.—When the open circuit occurs on number 2 motor, the number 1 motor can be operated with the indicator pointer of the controller when midway between the fifth and sixth positions. When the open circuit occurs in number 1 motor the number 2 motor cannot be operated until the controlling cylinder is placed in connection with the first parallel position of controller.

Q. What is the correct position of a motorman in operating a car?

A. A motorman should stand erect, with right foot slightly in advance of the left, the left hand on power handle of the controller and right hand on the brake handle facing forward.

Q. Supposing you are assigned to a car to begin your day's work and you found that the controller handle could not be thrown beyond the last series position, what would be the cause and where would you look for trouble?

A. The cause would be that a motor is cut out with the cut-out switch in that controller, and the proper course to pursue in such a case would be to notify the shop foreman relative to the fact, or the man in charge.

Q. What precaution should be taken, after having made a stop at a railroad crossing, and the conductor has gone ahead to flag same, relative to the starting of the car?

A. The motorman should always make sure that there are no passengers alighting to or from the car.

Q. Suppose a contact wiper in the controller becomes bent or broken, how could this be remedied?

A. The most practical and reliable method to overcome the difficulty would be to take a contact wiper from opposite controller on the car.

SEMAPHORE SIGNALS.

Q. What are railway semaphore signals?

A. It is a device used by railway companies for the purpose of conveying a signal at a distance either for danger or for safety, of which there are two classes, one known as the home signal and the other as the distant signal.

Q. How is the home signal to be designated from the distant signal?

A. The home signal is designated by the blade with the square end and is usually painted red. The distant signal is designated by the fish-tail blade, and is usually painted green. These are known as day signals.

Q. How are they designated at night?

A. By means of different colored lights. The home signal, when set for danger, shows a red light, and when set for safety a white light. The distant signal is supplied with a

green lens, and when the green light is displayed it denotes that precaution should be taken on approaching the home signal, and when the white light is displayed it denotes safety.

Q. If a green light is displayed on the distant signal, and after passing it the home signal showed a red light, what should be done?

A. The car should be brought to a standstill.

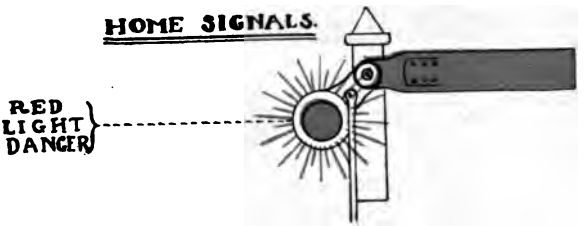
Q. Is there more than one semaphore arm on the same post?

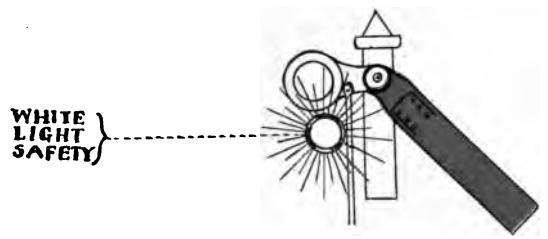
A. There are in some cases two or more.

Q. What do these arms represent and how explained?

A. When three semaphore arms are located on the same post they govern three tracks. The arm at the top governs the extreme right-hand track, the next lower or middle arm governs the track to the left of that track, while the lower arm governs the third track, or the track to the extreme left.

HOME SIGNALS.





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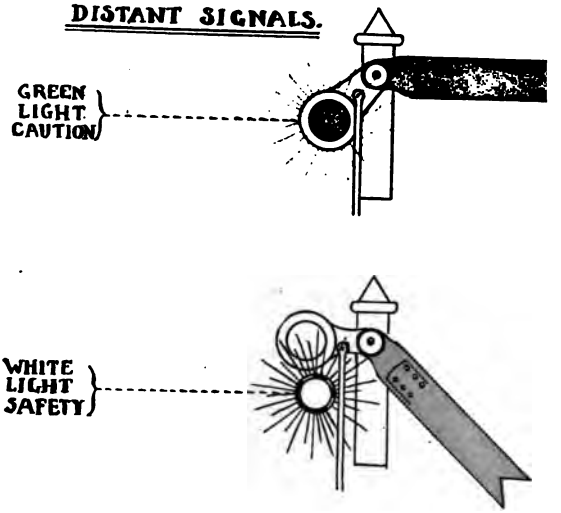

A BRIEF DESCRIPTION OF THE CONDUIT STREET RAILWAY SYSTEM.

The conduit electric railway system differs somewhat from that of what is known as the overhead trolley system. The conductors of the conduit system are composed of angle iron bars supported by insulators. One bar is known as the positive bar, while the other is known as the negative bar. These bars are also sometimes called contact bars, or channel rails, and are placed about six inches apart and below the surface of the street. The current is conducted to the motors by means of what is known as the conduit plow, upon which is mounted the two sliding contact plates, one on each side of the plow, one acting as positive conductor and the other as negative conductor. The rails of this particular system are not bonded or connected, as on the overhead trolley system, as the circuit is completed by the negative return bar. The placing of feeders in connection with the system is similar to that of the overhead trolley system.

SERIES OF QUESTIONS AND ANSWERS RELATIVE TO THE OPERATION OF CARS OF THE CONDUIT SYSTEM.

Q. If a controller was out of order and could not be turned off, how would you open the circuit to the line to stop the car?

A. Turn off hood or canopy switch.

Q. What should be done before attempting any repairs?

A. Turn off both ground and automatic switches.

Q. If lights fail to light, what would you examine?

A. Automatic or ground switches. If switches are set right examine plow leads. If they should be disconnected and dragging on the ground, connect them at once.

Q. If automatic switches or fuses blow two or three times in succession, what should be done?

A. Locate and cut out the defective motor.

Q. If the plow is grounded or commenced to burn, what should be done?

A. The car should be kept moving, but not

with its own power if possible to avoid it. A car with the plow in this condition should have the automatic or ground switches turned off and be conveyed to a break in the underground conductor or a plow hatch, where the plow should be removed.

Q. If a car with a burning or grounded plow is left standing on the rail, what would be the result?

A. The underground conductor would be burned and destroyed.

NOTE.—In case a car becomes disabled and it appears that the plow springs or shoes are torn off, the motorman must warn his follower to run carefully over the place where he believes the damage occurred. If two cars lose power in succession, the motorman on the following car must be warned not to proceed until the underground conductors have been examined and put in order.

Q. If any of the circuit-breaking devices on the car were grounded or loose connections commenced to burn, what should be done?

A. Turn off automatic or ground switches.

If the switches were burning and could not be turned off disconnect the plow leads.

Q. How can you distinguish number 1 from number 2 controller?

A. By a short jumper wire in number 1 controller connecting cables known as E 2 X and T 2.

Q. Which end of the double-truck car is the short end?

A. The end that the plow is on or the end that the register is on.

POWER OFF AT BREAKS.

At points where there is a break in the underground conductor as indicated by marks on the surface of the streets, power must be turned off when the front end of single-truck or short end of double truck cars reach long mark, and may be turned on at short marks. If on the long end of a double-truck car, power may be held six feet over long mark, and must not be turned on until the front end of car passes six feet over short mark. When the power is turned off at the long mark, the circuit is opened in the controller and the blow-out magnet can control and

break the arc; but if the power is held on when passing over a break, the circuit is open at the underground conductor, where there is no blow-out magnet to break the arc, and the heat caused by the arc is so intense that the plow fuse is burned, plow springs weakened, and sometimes sets the plow afire, which would in most cases ground the section.

SPEED TABLE.

Rate Miles per Hour.	Time in Seconds to Travel One Foot.	Distance per Second. Ft. and In.	Distance per Minute.	
			Feet.	Blocks of 263 Feet.
1	.682	1′ 5½″	88	
2	.340	2′ 11⅛″	176	
3	.227	4′ 4⅝″	264	1
4	.170	5′ 10⅜″	352	1⅓
5	.136	7′ 4″	440	1⅔
6	.113	8′ 9½″	528	2
7	.097	10′ 3⅛″	616	2⅓
8	.085	11′ 8⅝″	704	2⅔
9	.075	13′ 2¼″	792	3
10	.068	14′ 8″	880	3⅓
11	.062	16′ 1½″	968	3⅔
12	.056	17′ 7⅛″	1,056	4
13	.052	19′ 0⅝″	1,144	4⅓
14	.049	20′ 6¼″	1,232	4⅔
15	.045	22′ 0″	1,320	5

CUT SHOWING "NOARK" FUSE BOX, WITH FUSE INSERTED, AND COVER THROWN BACK.

CUT SHOWING "NOARK" FUSE.

The above cuts show a "Noark" Fuse Box, with fuse inserted, and cover thrown back, also a "Noark" Fuse.

This equipment is manufactured by the H. W. Johns-Manville Company of New York. Some of the largest roads in the country are now using this style of fuse box.

The slate block, to which is attached the two binding posts, is firmly fixed and protected in a solid well-japanned cast iron box as shown in the illustration. This box has a hinged cover and spring snap catch, which allows the cover to swing back and makes the inside of the box easy to get at and the insertion of a fuse but a moment's work.

The "Noark" fuse is a vast improvement over the old-time ordinary bare wire or lead fuse for several reasons, chief of which are that they do not rupture with a loud report and a heavy flash which is so liable to frighten the passengers, causing them to jump off of the car while it is in motion, often resulting in a damage suit against the company; frightening horses, which might be near the car, and cause a runaway, besides blistering the varnish and paint and blackening up the sides of the car. This is a decidedly bad feature with the uncovered fuse, as sometimes before a car has been in service